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# MONTHLY WEATHER REVIEW

## JANUARY, 1933

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# MONTHLY WEATHER REVIEW

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VOL. 61, No. 1
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JANUARY, 1933

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## SOLAR ACTIVITY AND RADIO RECEPTION

By HARLAN T. STETSON, Director

[Perkins Observatory, Ohio Wesleyan University, Delaware, Ohio, May 27, 1932]

With the accumulation of solar observations, the study of the sun as a factor in the study of meteorological phenomena appears increasingly fruitful in scientific investigations. Close cooperation of the Weather Bureau with the United States Naval Observatory and the Yerkes, Mount Wilson, and Perkins Observatories makes possible the publication of data of the condition of the solar surface with scarcely, if ever, a missing date.

Many attempted correlations have been made between the so-called Wolfer sun-spot numbers and meteorological conditions, such as changes in temperature, precipitation, and barometric pressure, some of which are not without marks of significance. Measures in the variation of solar radiation at the Smithsonian Institution and the relative intensity of ultra-violet radiation as recorded at Mount Wilson and the desert laboratory in Arizona provide additional data of growing significance in correlation studies of solar and terrestrial phenomena.

The remarkable work of Douglass [1] in establishing the records of variable periods in precipitation over the centuries as concomitant with the variations in solar activity leave little doubt as to the reality of the ultimate importance of considering solar activity as a factor in climatic changes.

That a new means has become available of studying the correlation of solar activity with atmospheric phenomena through the advent of the radio appears to be rather definitely established through recent researches on the correlation of sun spots with radio reception.[2] The work of Austin,[3] at the Bureau of Standards, and the pioneer work of Pickard have established records of utmost significance. While the work of Austin at the Bureau of Standards has shown less definitely an obvious correlation between the intensity of radio reception and solar activity from measures in the region of long wave lengths, or low frequency, measures in the broadcast band have appeared to indicate most definitely that changes in the intensity of radio reception accompany changes in solar activity as exhibited by the frequency of sun spots.

Work in the broadcast zone was begun by G. W. Pickard [4] in his private laboratory at Newton Center, Mass., in 1926, and was later carried on by the writer at the Harvard Astronomical Laboratory, at Cambridge, Mass. The apparent concomitance in the changes of radio intensities as received from WBBM, Chicago, at Boston, with the inverted curve of sun-spot numbers is clearly shown in the accompanying diagram (fig. 1),

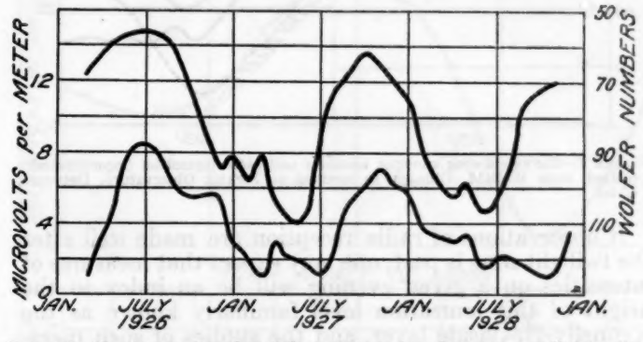


FIGURE 1.—Upper curve shows inverted sun-spot numbers; lower curve, radio-intensity measurements. Observations received at Boston from WBBM, Chicago

covering the years 1926—1928. Secondary peaks in the curve of sun-spot numbers traced over a considerable interval show the persistance of a 15-month subcycle in solar activity, which accounts for the three major peaks in the last maximum of the sun-spot curve. The 1920 peak, accompanied by a marked depression in the radio intensity curve, was predicted by Stetson and Pickard [5] in 1928, and the fulfillment of the prediction seems to give considerable support both to the hypothesis of the 15-month cycle and to that of the correlation of radio transmission with solar activity. It appears that the variation in the intesnity of the carrier wave as received at the recording apparatus may be attributed to a change in the hypothetical altitude of the Kennelly-Heaviside layer from which the sky wave is returned earthwards in long-distance transmission. At distances too remote from the sending station to be seriously affected by a ground wave the reflected sky wave appears to be the dominant factor in determing the intensities of signal strengths.

The most obvious effect of solar radiation upon radio phenomena is the well-known daylight and darkness

[1] Reports of the Conference on Cycles, p. 5. Carnegie Institution of Washington, 1929.
[2] Publ. Am. Astron. Soc., *6*, 244; Pop. Astron., *37*, 588; Journ. of the Franklin Institute, *210*, 4, 414 (October, 1930).
[3] Proc. Institute of Radio Engineers, *19*, 10, 1766 (October, 1931).
Proc. Institute of Radio Engineers, *15*, 2, 9 (1927); Pickard, Proc. Institute of Radio Engineers (December, 1927).
[4] Publ. Am. Astron. Soc., *6*, 244.

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effect, which unquestionably is due to the change of ionization level in the earth's atmosphere. One may regard the sun as a hot body continually discharging radiations or corpuscles which, striking the earth's atmosphere, eventually ionize it to a determined level during the hours of sunshine. With the approach of darkness, the ionizing effect of the sun being removed, an association takes place with the result that radio waves penetrate to a much higher level of the earth's atmosphere.

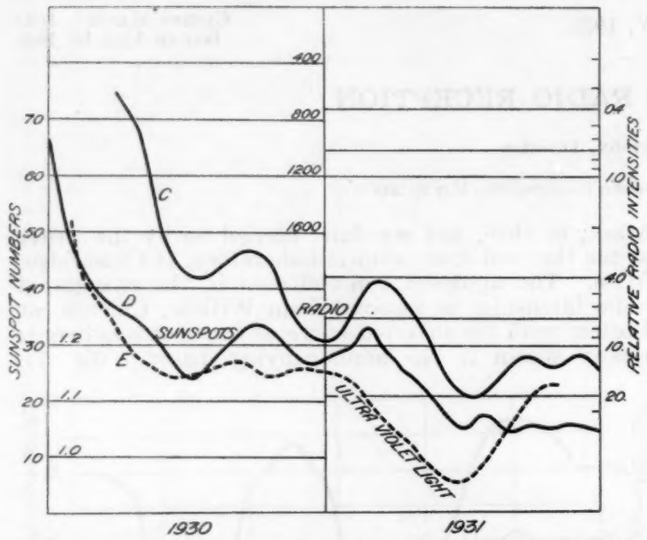


FIGURE 2.—Curve showing sun-spot numbers and radio intensities (logarithmically plotted) from WBBM, Chicago, as received at Perkins Observatory, Delaware, Ohio

If observations of radio reception are made well after the twilight zone is past, one may expect that measures of intensities on a given evening will be an index to the height of this ionization level familiarly known as the Kennelly-Heaviside layer, and the studies of such measures made over a long period of time may be expected to give results as to such periodic changes as may exist in this ionized layer as a function of solar activity. If, in times of high sun-spot numbers, more electrons are emitted from the sun, or if in some way concentrated bundles of electrons are directed earthward, the increased ionization resulting in the earth's upper atmosphere should become observable through changes in the intensity of radio receptivity.

Two hypotheses may be advanced to account for the lowering level of the Kennelly-Heaviside layer with the increase in sun-spot numbers—first, that on account of the general condition of solar activity emission actually rises over the whole sun; and second, that the electromagnetic fields of the sun spots concentrate the stream in the direction of the axis of the cyclonic whirls in the sun spots so that when they appear on the surface of the sun in the general direction of the earth, the earth is subjected to a heavier bombardment of emitted particles, thereby increasing the electron density of the upper atmosphere and effectively lowering the Kennelly-Heaviside layer. Studies of the radio reception records now available seem to favor the second hypothesis, which by no means excludes, however, the first hypothesis mentioned.

With the establishment of a research program at the Perkins Observatory in 1930, automatic recording apparatus, made possible through a grant from the Rumford Committee of the American Academy of Arts and Sciences was set up in the laboratory of the Perkins Observatory and put into operation at the beginning of March, 1930. Meanwhile the series of observations in the region of Boston have been continued through the cooperation of Professor Kenrick, with apparatus at Tufts College, in Massachusetts.

At the present date of writing (April, 1932) two years of observations of WBBM, Chicago, have been received at Delaware, Ohio. The mean intensities in the received carrier wave have been automatically recorded and form the basis for a curve of three months' moving averages, depicted in Figure 2. The ordinates represent for the lower arm in Figure 2 sun-spot numbers based on three months' moving averages, and for the upper curve corresponding values for microvolts in the antenna laid out logarithmically. It will be observed in the upper curve that the numerical values of the ordinates increase downward in order that the radio reception curve may conveniently parallel the sun-spot curve, thus exhibiting the inverse relationship. A glance at the curve shows that while sun-spot numbers have decreased some 50 per cent during the last year, radio reception has increased 400 per cent. The fact that the same general trend of increasing reception with decreasing solar activity appears to be followed over the 300-mile path between Chicago and Delaware, Ohio, as was exhibited over the 900-mile path between Chicago and Boston, suggests that the disturbance of the Heaviside layer through solar activity is sufficiently extensive to draw rather more general conclusions than we had at first dared suppose.

In the apparatus set up at Perkins Observatory the same general type of arrangement has been maintained as was used at Boston. A superheterodyne receiver, schematically shown in Figure 3, feeds through an oxide

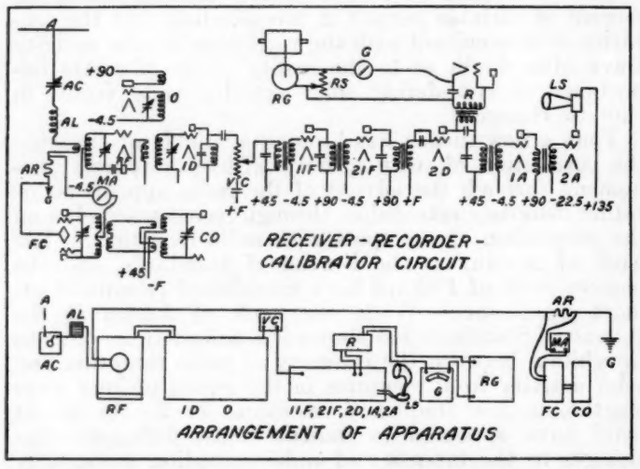


FIGURE 3.—Diagram of radio receiving circuit for recording intensities in the carrier wave

rectifier in the last stage of amplification into one arm of the Wheatstone bridge of the automatic recorder. The automatic recorder employed is of the Leeds and Northrup single-point type in which a compensation for fluctuation in voltage in the unknown arm of the bridge is graphically traced by a pen mechanically connected with the movable

contact on a slide wire. The motive power is furnished by a synchronous motor whose motion is communicated to the compensating resistance by the excursions of the needle of the galvanometer connected across the arms of the bridge in the usual way.

To properly standardize the receiving set, including the antenna, a local oscillator tuned to the frequency of the broadcasting station is used each night to propagate a

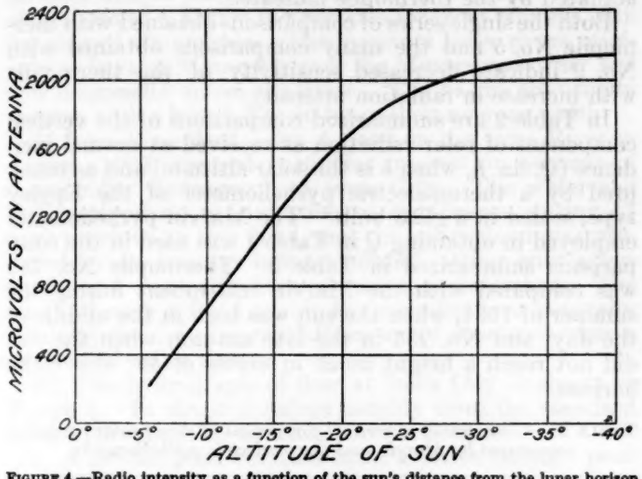


FIGURE 4.—Radio intensity as a function of the sun's distance from the lunar horizon for Delaware, Ohio

wave of known intensity whose measured strength is recorded on the receiving apparatus, thus giving the constant of the apparatus for each night's observations. The deterioration of tubes and the changing resistance of the antenna through varying conditions of weather or humidity therefore does not enter into the reduced values representing signal strengths for a given evening. During the early part of the investigation the observing data have been restricted to the 9 to 10 hour in the evening (E. S. T.), and the averages of signal strengths for twelve 5-minute intervals have been taken from the graph to derive the index of intensities for a given evening.

Inasmuch as the 9 to 10 p. m. hour comes closer to the twilight zone in summer than in winter an investigation has been conducted during the last two years to determine the intensity of signal strengths as a function of the distance of the receiving station from the subsolar point. Various investigators have from time to time studied the changes of signal strength with the change in the solar hour angle. As the varying seasonal change in the declination of the sun, however, materially effects the distance of the observer from the twilight band, it was believed that the correlation of radio reception with negative solar altitudes would more effectively represent a correction curve for twilight effect.

The correction curve given in Figure 4, as a result of an extensive investigation by Mr. Marvin Cobb, of the Perkins Observatory staff, is based on more than 2,000 hours of observation extending over 500 nights from observations made between 9 p. m. and 2 a. m. In arriving at the mean curve in Figure 4 a first approximation has been applied to correct for the general trend of the effect of solar activity during this interval. The application of Figure 4 as a correction curve to the last two years' observations materially changes the curve of directly observed intensities.

In an investigation to determine what effect, if any, the moon may have upon the recorded values of radio intensity, a preliminary study has been made at the Perkins Observatory of observational data of the Cambridge-Boston series of 1926–1929.[6] The curve in Figure 5 is the result of an analysis of these data, which appears to indicate a very considerable correlation between the intensity of radio reception and the altitude of the moon, the altitude of the moon representing the complement of the observer's distance from the sublunar point. The fact that radio intensities appear to be markedly greater when the moon is below the horizon suggests that we have here further means for corrections of radio intensities which may be applied to the curve of radio reception for studying the interrelationship of solar and radio phenomena. A cursory glance at the data in hand suggests at the present writing that corrections for the lunar effect will become significant in further altering the curve of radio intensities which may result in an even closer correspondence of the radio curve with solar activity. Extensive investigations are now in progress at the Per-

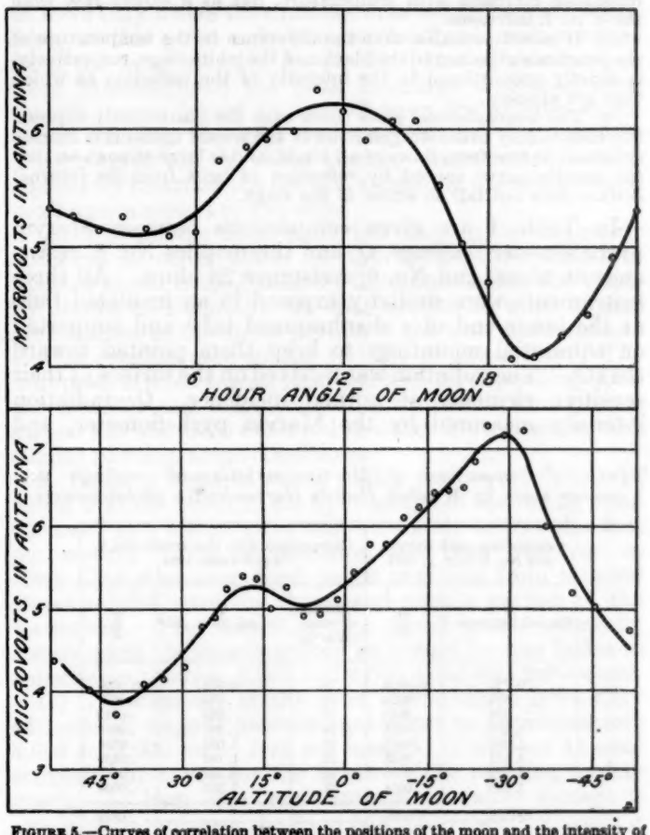


FIGURE 5.—Curves of correlation between the positions of the moon and the intensity of radio reception

kins Observatory concerning this lunar effect, the results of which will be published at a later date.

Apparatus has now been installed for extending these studies to higher levels of the Kennelly-Heaviside layer through the recording of signals of high frequency from a cooperating station at the Warner and Swasey Observatory, in Cleveland.

[6] Publ. Am. Astron. Soc., 6, 244.

# THE MAGNITUDE OF THE ERROR IN MEASUREMENTS OF THE SOLAR RADIATION RECEIVED ON A HORIZONTAL SURFACE ARISING FROM THE ASSUMPTION THAT THE RATIO BETWEEN RADIANT ENERGY RECEIVED AND ELECTRICAL ENERGY RECORDED IS A CONSTANT

By HERBERT H. KIMBALL and IRVING F. HAND

In a recent paper [1] attention is invited to the error arising from the use of a constant factor to reduce records from pyranometers to heat units without regard to the angle of incidence at which the heat rays strike the receiving surface of the instrument, special reference being made to a paper by Kimball and Hobbs [2] in which this error is not mentioned.

In this last paper reference was made to other sources of error, as follows:

(1) The e. m. f. generated in the thermopile is not strictly proportional to the difference between the temperatures of the junctions attached to the black and the white rings, respectively. The efficiency of the thermopile appears to increase with temperature difference, and presumably with the temperature of the pile.

(2) The resistance of all the wires except that in the swamping resistance increases with temperature, but at a slower rate than the e. m. f. increases.

(3) It is not probable that the difference in the temperature of the junctions attached to the black and the white rings, respectively, is strictly proportional to the intensity of the radiation to which they are exposed.

(4) The hemispherical glass cover over the horizontally exposed thermopile may cause irregularities in the record unelss it is exactly spherical, is free from flaws of all kinds, and is large enough so that the caustic curve caused by reflection of light from its internal surface does not fall on either of the rings.

In Table 1 are given comparisons between Marvin pyrheliometer readings, $Q$, and thermopiles No. 5, resistance 86 ohms, and No. 9, resistance 28 ohms. All three instruments were similarly exposed in an insulated bulb at the lower end of a diaphragmed tube and supported on equatorial mountings to keep them pointed toward the sun. The radiation was received on the surface of their sensitive elements at normal incidence. $Q$ = radiation intensity measured by the Marvin pyrheliometer, and $S$ = the relative intensity indicated by the recorder actuated by the thermopile indicated.

TABLE 1.—*Comparison of Marvin pyrheliometer readings with records made by Weather Bureau thermoelectric pyrheliometers*

| Comparison with thermopile No. 5, Apr. 2, 1923 | | Comparison with thermopile No. 9, April–June, 1924 | | |
|---|---|---|---|---|
| $Q$ Gr. cal./min. cm² | $\frac{Q}{S}$ | Number of comparisons | $Q$ Gr. cal./min. cm² | $\frac{Q}{S}$ |
| 0.729 | 0.0634 | 24 | 0.676 | 0.0624 |
| .816 | .0628 | 18 | .743 | .0637 |
| .979 | .0648 | 22 | .825 | .0642 |
| 1.074 | .0624 | 24 | .947 | .0650 |
| 1.091 | .0634 | 26 | 1.032 | .0654 |
| 1.174 | .0638 | 39 | 1.162 | .0659 |
| 1.222 | .0636 | 48 | 1.238 | .0657 |
| 1.309 | .0664 | 21 | 1.335 | .0658 |
| Mean | .0638 | | | .0648 |

[1] Middleton, W. E. Knowles. A source of error in measuring radiation on a horizontal surface. Gerlands Beiträge zur Geophysik.

[2] Kimball, H. H., and Hobbs, E. H. A new form of themoelectric pyrheliometer. MONTHLY WEATHER REVIEW, Vol. 51, pp. 239–242, 1923.

Both the single series of comparisons obtained with thermopile No. 5 and the many comparisons obtained with No. 9 indicate decreased sensitivity of the thermopile with increase in radiation intensity.

In Table 2 are summarized comparisons of the vertical component of solar radiation as received at normal incidence ($Q$, sin. $h$, when $h$ is the solar altitude) and as measured by a thermoelectric pyrheliometer of the Eppley type, sealed in a glass bulb.[3] The Marvin pyrheliometer employed in obtaining $Q$ in Table 1 was used in the comparisons summarized in Table 2. Thermopile No. 245 was compared with the Marvin instrument during the summer of 1931, when the sun was high in the middle of the day, and No. 255 in the late autumn when the sun did not reach a height much in excess of 40° above the horizon.

TABLE 2.—*Comparison of vertical component of direct solar radiation measured by Marvin and thermoelectric pyrheliometers*

| Range of intensities, gr. cal./min./cm² | No. 245, number of comparisons | Mv. per gr. cal. | Range of mv. values | No. 245, number of comparisons | Mv. per gr. cal. |
|---|---|---|---|---|---|
| Less than 0.26 gr. cal | 40 | 7.13 | 8.14–6.32 | 49 | 7.52 |
| 0.26 to 0.50 gr. cal | 119 | 7.41 | 8.11–6.71 | 105 | 8.30 |
| 0.51 to 0.75 gr. cal | 126 | 7.76 | 8.12–7.33 | 61 | 8.32 |
| 0.76 to 1.00 gr. cal | 88 | 7.73 | 8.05–7.32 | 16 | 8.34 |
| In excess of 1.00 gr. cal | 118 | 7.75 | 8.11–7.45 | | |

The data in these two tables have not been arranged in just the same way, but they show clearly that while when exposed with their surfaces normal to the incident solar rays the thermopile is less effective with high solar radiation intensity than with low intensity, the opposite is true when the thermopile is exposed with its surface horizontal, and this decrease in sensitivity of the thermopile with low radiation intensity, or what is the same thing, with low altitude of the sun, may be attributed to lower absorbing power, or higher reflecting power of the surfaces with increase in the angle of incidence. The comparisons in Table 2 do not indicate that this variation is so great as to introduce serious errors into the hourly amounts of radiation received upon a horizontal surface if a mean value of $Q/S$ obtained from comparisons similar to those given in Table 2 is employed, especially since with low sun the direct solar radiation component of the total radiation received on a horizontal surface becomes relatively less and less important.

[3] The method by which the vertical component of solar radiation received on a horizontal surface is measured is described and illustrated in the paper by Kimball and Hobbs (see footnote 2, above), pp. 241–242, and fig. 4.

# CERTAIN FLOOD-FLOW PHENOMENA OF IOWA RIVERS

By FLOYD A. NAGLER, Professor of Hydraulic Engineering

[University of Iowa, Iowa City, Iowa, April 27, 1932]

[This paper was prepared for presentation at the Hydrology Section of the American Geophysical Union]

1. *Elongated watersheds of Iowa streams.*—The characteristic long and narrow watersheds of Iowa rivers produce unique phenomena in flood hydrographs capable of analysis to a degree not possible for most streams with fan-shaped watersheds. The principal Iowa rivers originate in Iowa or Minnesota near the Minnesota border and flow diagonally across the State. The basins are usually narrow, with a length 8 to 30 times their average width.

2. *Iowa River flood.*—(*a*) A flood on the Iowa River in August, 1929, aroused particular interest on account of the peculiar hydrograph at Iowa City. The watershed had received no precipitation of significance during 17 days previous to this flood, and the entire flood was produced by an isolated intense rainfall lasting only a few hours and centrally located on the watershed. The study of such a flood avoids the complications generally resulting from storm rainfall unevenly scattered over a number of rainy days.

(*b*) The hydrograph of flow at Iowa City is shown in Figure 1. In shape it differs notably from the standard flood hydrograph in at least two particulars:

1. A double peak resulted from a single isolated peak of rainfall.

2. A sharp break occurred in the falling flood hydrograph, accompanied by an increase rather than a decrease in the rate of depletion of the flow.

(*c*) Apparently, both of the above phenomena may result from the physical characteristics of the river above Iowa City. Such phenomena no doubt occur in the floods of other streams, where the causes are less easily disclosed.

3. *Storm rainfall.*—The distribution of the storm rainfall of August 2, which caused the flood, is shown in Figure 2. Rainfall intensities were observed at Iowa City, 70 miles from the center of the storm. This was the only point within the storm area at which such observations were available. The graph of the Iowa City rainfall is reproduced in Figure 3, showing that the most intense precipitation was received between 4 and 5.45 a. m. on August 2. Near the center of the storm at Toledo, it was reported that most of the 8-inch rainfall was received between 11 p. m. on August 1 and 3 a. m. on August 2.

4. *Cause of double-flood peak.*—(*a*) The manner in which the precipitation was received offers no apparent solution for the double-flood peak. Likewise a long river with only minor tributaries entering along its stem would not normally be expected to cause the phenomenon shown in Figure 1.

(*b*) The first peak undoubtedly resulted from rapid run-off from the hilly country extending upstream for 25 miles (to A, fig. 2) from the vicinity of Iowa City. In this region the river flows through a deep narrow valley with a flood plain extending only a few hundred feet outside of the main channel of the stream. Thus the first flood peak had all of the characteristics of rapid run-off combined with limited channel storage. The local freshet from this region actually receded before flood water was received from the heavier storm rainfall which fell on the portion of the watershed immediately upstream.

(*c*) The second peak following five days later had all the characteristics of flow retarded by storage. In this case, the storage utilized was in the valley of the stream itself. From (point A, fig. 2) to (point B, fig. 2 ) which is upstream about 100 miles, the valley of the Iowa River is 1 to 3 miles in width, with a present flood plain which is nearly a mile wide in places. When the river rises above an 8-foot stage, the flow spreads laterally over this flood plain, resulting in a reduction in the flood peak by the storage of a large volume of flood water in the valley. The rate of progress of the flood peak is likewise retarded. The simultaneous flood hydrograph of the Iowa River at the Marshalltown gage near the upper end of the storage area is also shown in Figure 1. At Marshalltown the river drains a watershed of only 1,500 square miles, yet it is noted that the peak flood discharge was higher than that at Iowa City where the drainage area is 3,230 square miles. Also, at this point only one normal flood peak resulted from the same storm. As the flood moved downstream from Marshalltown the peak discharge decreased even though it was joined by run-off from the smaller tributaries draining the land receiving the heaviest rainfall. This is typically a valley-storage phenomenon, which effectively retarded the run-off, spreading the second flood peak over a period of five days.

(*d*) The double flood peak has been quite commonly observed in other floods on the Iowa River whenever isolated storm rainfall falls on the watershed in the vicinity shown in Figure 2. It does not result when storms are confined to the upper portion of the watershed or from storms concentrated in the vicinity of Iowa City. The first peak is often higher than the second, depending upon the location and magnitude of the storm. This phenomenon has also been observed on other Iowa streams with similar physiographic conditions.

5. *Cause of break in rate of falling flood.*—(*a*) It will be noted that the break in the hydrograph of the falling flood occurred at a discharge of approximately 6,000 cubic feet per second. This phenomenon has been observed at Iowa City whenever flood peaks originate from isolated storm rainfall over the upper and middle portion of the watershed. The break in the flood graph generally occurs when the receding flood at Iowa City has fallen to a discharge between 6,000 and 8,000 cubic feet per second.

(*b*) The capacity of the Iowa River above Iowa City at bankfull stage is likewise equivalent to approximately 6,000 to 8,000 cubic feet per second. This fact at once suggests the cause for the break in the receding hydrograph. As long as a large amount of valley storage is available to replenish the flood flow, the rate of recession is slow, but when this reservoir of flood water has been exhausted, the flood flow is sustained only by the relatively small amount of storage within the river banks. Hence, as some have expressed it, "the bottom appears to drop out of the river," and the stream rapidly falls to a normal stage, where the discharge can be maintained by the inflow from the various tributaries. In floods, with rainfall scattered in time and distribution over the watershed, the above effect is often entirely obscured.

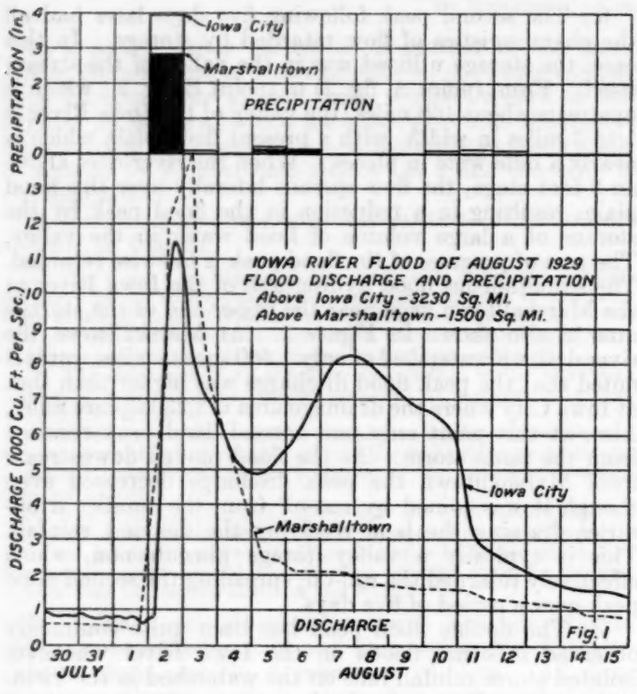

Fig. 1

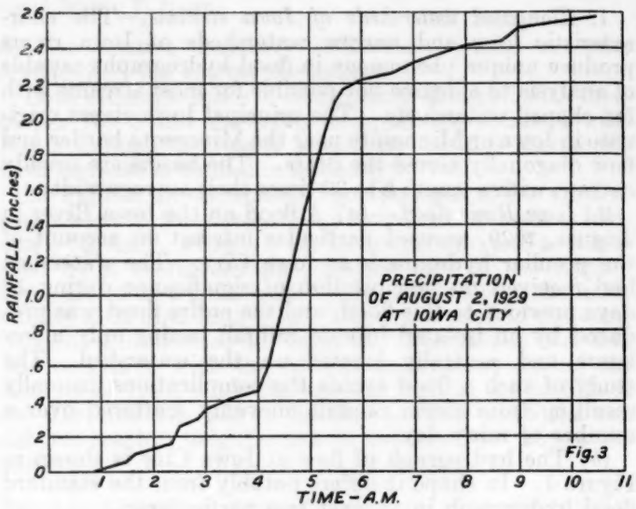

Fig. 3

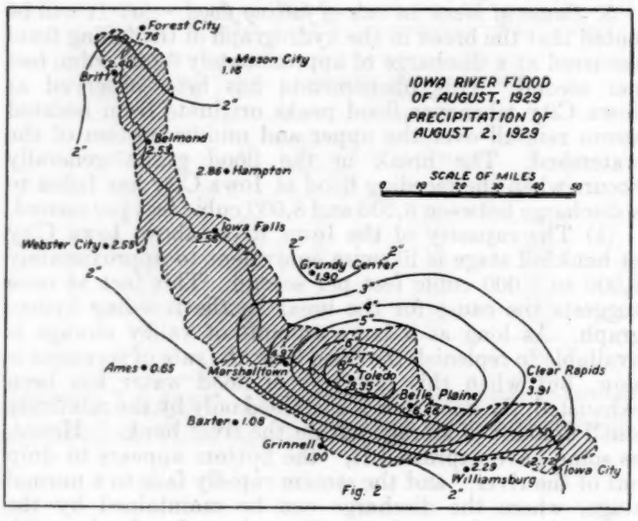

Fig. 2

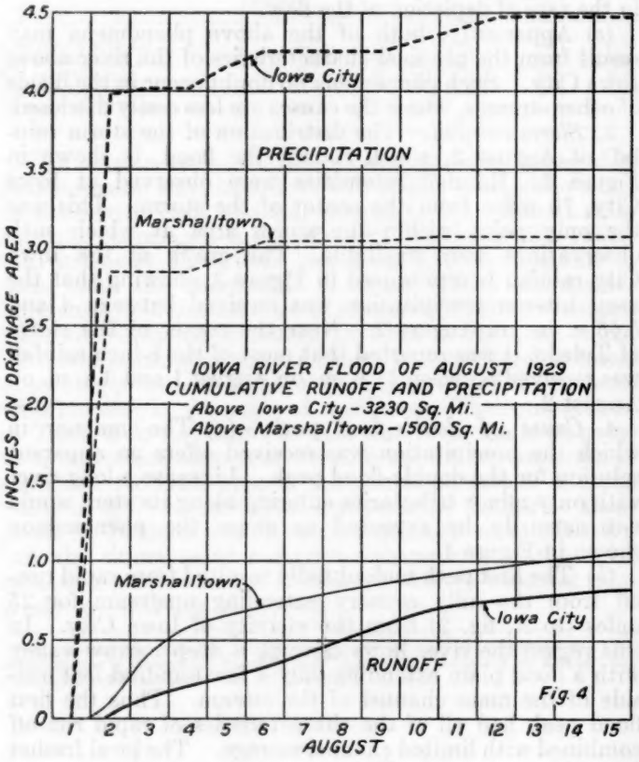

Fig. 4

6. *Percentage of run-off.*—(*a*) It is fortunate for agriculture in Iowa that the percentage of run-off from storm rainfall is small. In the August, 1929, flood, the percentage of the precipitation reaching the stream, amounted to only 18.3 per cent at Iowa City and 33.7 per cent at Marshalltown. Experiments indicate that very little, if any, of the midsummer precipitation percolates deep enough into the soil to replenish the ground water and replenish the supply available for subsequent run-off. Hence, the balance of the water was either evaporated immediately or stored in the upper layers of the soil for future evaporation and plant use. The graph showing the comparison of the cumulative run-off and precipitation is shown in Figure 4.

(*b*) In the following table, the percentage storm rainfall appearing as flood run-off is listed for other midsummer floods on Iowa streams. On the larger basins, the flood run-off rarely exceeds 30 per cent of the precipitation, although occasionally on some smaller watersheds almost 70 per cent of the storm rainfall has reached the streams.

TABLE 1.—*Percentage run-off of typical Iowa summer floods*

| River | Gaging station | Drainage area, square miles | Date | Total precipitation, inches | Total run-off, inches | Per cent run-off of precipitation |
|---|---|---|---|---|---|---|
| Iowa | Iowa City | 3,230 | May-June, 1903 | 7.10 | 1.58 | 22.3 |
| | | | May-June, 1918 | 6.99 | 2.36 | 33.8 |
| | | | June-July, 1924 | 4.72 | .84 | 17.8 |
| | | | August, 1929 | 4.48 | .82 | 18.3 |
| Do | Marshalltown | 1,500 | do | 3.07 | 1.05 | 34.2 |
| Cedar | Cedar Rapids | 6,570 | May-June, 1903 | 5.75 | 1.09 | 19.0 |
| Des Moines | Kalo | 4,290 | May-June, 1915 | 5.34 | 1.56 | 29.2 |
| | | | July, 1920 | 4.53 | 1.36 | 3.00 |
| Do | Keosauqua | 14,090 | May-June, 1903 | 8.53 | 2.59 | 30.4 |
| | | | June, 1905 | 1.92 | .49 | 25.6 |
| | | | May-June, 1917 | 5.86 | 1.79 | 30.5 |
| Raccoon | Van Meter | 3,450 | May-June, 1915 | 6.46 | 1.81 | 28.0 |
| | | | May-June, 1917 | 5.95 | 1.88 | 31.6 |
| | | | September, 1926 | 4.62 | 1.79 | 38.8 |
| Skunk | Coppock | 2,915 | May-June, 1917 | 7.16 | 2.89 | 40.0 |
| | | | May-June, 1918 | 7.16 | 2.00 | 28.0 |
| | | | June-July, 1924 | 3.78 | 1.36 | 36.0 |
| | | | September-October, 1926. | 12.56 | 4.58 | 36.4 |
| Do | Augusta | 4,285 | May-June, 1917 | 6.91 | 2.90 | 42.0 |
| | | | May-June, 1918 | 6.10 | 1.64 | 26.9 |
| | | | June-July, 1924 | 4.38 | 1.80 | 41.1 |
| | | | September-October, 1926. | 12.85 | 5.40 | 42.0 |
| Do | Ames | 315 | June-July, 1924 | 2.54 | 1.40 | 55.1 |
| | | | do | 2.29 | 1.54 | 67.3 |
| Squaw Creek | do | 205 | September-October, 1926. | 12.85 | 3.35 | 26.1 |
| | | | June, 1926 | 2.65 | .49 | 18.5 |
| | | | September, 1926 | 1.98 | .78 | 39.4 |
| | | | do | 1.84 | .82 | 44.5 |
| | | | May, 1927 | 1.04 | .32 | 30.7 |
| | | | do | 1.23 | .59 | 48.0 |
| | | | do | .59 | .41 | 69.5 |
| | | | June, 1927 | 4.88 | .05 | 62.4 |
| | | | June, 1928 | 2.06 | .52 | 25.0 |
| Ralston Creek | Iowa City | 3.0 | July, 1928 | 1.35 | .19 | 13.8 |
| | | | do | 1.07 | .45 | 41.7 |
| | | | August, 1928 | 1.61 | .61 | 37.9 |
| | | | do | 3.30 | .90 | 27.0 |
| | | | June, 1929 | 1.77 | .34 | 25.4 |
| | | | June-July, 1929 | 2.54 | .71 | 27.9 |
| | | | August, 1929 | 2.76 | .76 | 27.5 |
| | | | June, 1930 | 4.17 | 1.52 | 36.3 |
| | | | do | 1.11 | .19 | 17.2 |
| | | | September, 1930 | 5.07 | 1.28 | 25.2 |

# THE TECHNICAL USE THAT ENGINEERS MAKE OF UNITED STATES WEATHER BUREAU OBSERVATIONS

By CHARLES H. LEE

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The work of the civil engineer embraces the planning, construction, and operation of both private and public enterprises and improvements. In connection with these activities he probably makes use of a greater variety of meteorological data than any other class of citizens, and in so doing affects the welfare of many people. It should therefore be of interest to meteorologists to know of some of the technical uses that engineers make of United States Weather Bureau observations. These are outlined in this paper together with suggestions as to ways in which the value of the observations could be increased.

## PRECIPITATION

Precipitation is one of the most important classes of meteorological data which the engineer, and especially the hydraulic engineer, uses. It is fundamental to the planning of many projects and is very important in the design of hydraulic structures. It is necessary to know not alone the quantity of precipitation during long periods of time such as months, years, and groups of years, but also the rate or intensity for short periods of minutes and hours. The character of the precipitation, whether rain or snow, is also important.

*Quantity.*—Knowledge regarding the quantity of precipitation or depth in inches falling during periods of 24 hours or more, is of greatest importance in making water supply estimates for new hydraulic projects and for enlargement of existing systems. The proposed use of water may be for one of a great variety of purposes, such as domestic, industrial, municipal, irrigation, hydroelectric power, navigation, mining, or recreation. In every instance, however, it is necessary to know definitely whether sufficient water is available for the proposed use, both in the dryest season of the year and also during the dryest year which may be expected to occur. Streamflow measurements are of course depended upon to the extent available, but must usually be supplemented by studies of precipitation. The character of records required for this purpose range from long term average monthly and annual precipitation extending over periods of 50 or more years, to the actual precipitation which occurred on a specific day or during a certain storm. The data published in the monthly issues of Climatological Data are as much sought after in this connection as are the annual summaries or the occasional long-term summaries issued by the bureau.

In regions where there is a definite winter rainy season, such as on the Pacific coast of the United States, the compilation of precipitation data on the basis of the season instead of the calendar year is of great benefit to engineers, for it permits of immediate use of the data in water supply studies without the necessity of laborous preliminary computations. Precipitation records have been published

by the Weather Bureau in this form in recent years, at least for the California section, using the period July 1 to June 30, and have been a source of great satisfaction to engineers. Seasonal compilations show clearly the character of the rainy season, whether wet or dry, and permit of the direct comparison of stream flow with the precipitation which produces it.

There is great variety in the application which is made of quantitative precipitation data in water-supply studies. The principal use is in supplementing stream-flow records. By their use it is possible to estimate the normal or flood flow of surface streams supplied by run-off from precipitation occurring during periods or at points for which stream-flow observations are not available. These studies enable the engineer to determine whether storage is necessary to produce the required water supply, and if so, the reservoir capacity which will be necessary. In recent years more and more attention has been given to ground water as a source of supply. As precipitation is an important source of ground water, this has led to the investigation of the absorption from precipitation by the soil and other natural formations. This involves the study of precipitation from each individual storm in connection with soil moisture and evaporation. Studies of this nature enable the engineer to determine the extent and reliability of the flow from springs and the amount of ground water which is permanently recoverable by pumping from wells. Precipitation, in addition to being the source of stream flow or ground water used in irrigation, is frequently a direct source of soil moisture for growing agricultural plants. The ascertainment of what proportion of the annual plant requirements will be thus obtained directly, is of great importance in certain localities in determining the supply to be provided for irrigation works.

Another use of precipitation data is in forecasting the current season's supply as an aid to operation of existing water systems. This is of particular value where precipitation occurs as snow at high elevation and the melting period carries over into the summer. Elaborate snow surveys are now made during the winter and spring months of each year by various State, Federal, and private agencies throughout the West. In compiling the results of such surveys, extensive use is made of Weather Bureau precipitation data in comparing the observations with normal and in preparing the forecast for areas of early snow melting. The results of the surveys are widely sought by municipalities, water districts, and water and power companies, as the basis for making water contracts and planning each year's operations.

An entirely different use of quantitative precipitation data is that in connection with the design of land-drainage projects. In this case it is desired to determine the quantity of water absorbed by the soil from precipitation and which is to be removed by drainage works. This information is essential in determining the sizes of drain pipe and drainage outlets, the capacity of drainage pumps, etc. Daily and storm records are sought for this purpose as well as the amount of precipitation during longer periods.

*Isohyetose maps.*—It is frequently necessary in making water-supply studies to prepare isohyetose maps, or maps showing lines of equal depth of precipitation, either for a single storm, a whole season, or as an annual average during a long period. For general study such a map might cover some large geographical or political unit, but for specific studies it would be confined to a single watershed or group of adjacent watersheds. A proper geographic distribution of precipitation stations is of great importance in the preparation of such a map, since topography and slope is a primary factor in local precipitation. If the watershed is one of low relief and well settled, there may be but little local variation and existing stations may be adequate. If, however, part or all of the watershed is mountainous and sparsely settled, the existing stations will probably be inadequate for the purpose. There are frequent instances in the mountainous portions of the West where differences in average annual precipitation of 500 to 1,000 per cent occur within distances of from 10 to 40 miles. A careful local study of the relations of precipitation and elevation on windward and leeward slopes of mountain ranges may sometimes help to supplement a deficiency of mountain stations, but on the Pacific slope there are many very important watersheds which have too few stations within or even near them to make feasible the construction of isohyetose maps. The value of these maps is so great in a State such as California, where every drop of water is being inventoried and plans and cost estimates prepared for its ultimate use, that a very definite effort would be justified to overcome this deficiency. It would not necessarily involve a great increase in the total number of precipitation stations, but certainly a redistribution of stations with respect to critical topographic position would be required. Such a program might well include regular and cooperative stations maintained by the Weather Bureau as well as those maintained by private or municipal agencies.

*Intensity of precipitation.*—Increasing density of population and the development of the automobile have created a great popular demand for paved streets and highways, which in turn have given rise to the necessity of providing storm drainage. The latter may be accomplished by the construction of a simple culvert under a surfaced thoroughfare, or may involve the construction of an extensive system of storm sewers, or even the intricate combination of flood control reservoirs and artificial channels costing millions of dollars, such as being built for protection of the thickly populated areas of Los Angeles County, Calif. Regardless of the magnitude of the improvement, the determination of the quantity of water to be carried, and hence the required size of the pipe, conduit, open channel, or capacity of flood control reservoir, can best be determined from records of maximum rainfall intensity, that is, the greatest quantity falling during periods of five minutes and more up to several hours but usually less than 24 hours. By study of the flood run-off characteristics of the tributary drainage area, together with actual correlation of time of occurrence and intensities of heavy rainfalls and resulting flood flows at any point, it is possible to establish definite relations between rainfall and flood run-off intensities.

Such data can only be obtained by installation of an automatic rainfall recorder and careful study of the record sheets. In order to be of greatest usefulness such a record should include the storm of maximum intensity to be anticipated in the region, and hence the longer the period covered, the more valuable is the record. For large storm drainage systems it is necessary to have several such records, especially where a portion of the drainage area is mountainous. The U. S. Weather Bureau obtains such data at important population centers and much use is made of them as a basis for storm sewer and culvert design. The originals [W. B. Form 1017–Met'l] of such records are sent to Washington, D. C., for filing, and it would

often be of convenience to engineers if photostat negatives of these records were kept in the office of origin. In the more thinly populated areas there is very little data available, and for design of highway and railway culverts, flood control reservoirs, reservoir spillways, etc., it is still necessary to use assumptions in the design of waterway areas.

*Character of precipitation.*—In making water-supply estimates it is very important to have knowledge of the character of precipitation, whether rain or snow, and if the latter, the equivalent depth of water. Snow falling at high altitudes melts slowly and is the equivalent of reservoir storage in maintaining summer streamflow. It is very essential, however, to know the equivalent depth of water of the snow catch or the water content of snow on the ground. In the published records of precipitation falling as snow the catch is reduced to equivalent water, but there is no information regarding the water content of snow on the ground. This would be a very useful addition to the extensive snowfall records regularly published by the Weather Bureau.

### TEMPERATURE

The meteorological data next to precipitation in importance to the engineer is probably air temperature. He is interested both in average values and in extremes, especially where minimum values go below freezing. Daily, monthly, annual, and 10-year annual averages, as published by the Weather Bureau, are all in demand. One of the important uses of such data is in the planning and financing of irrigation systems. Temperature controls the length of the irrigation season, the character and variety of crops which can be successfully grown, and the number of crops which can be raised each year. Knowledge of these is essential for adequate preliminary investigation of irrigation projects and the financial success of such projects frequently depends upon the availability of complete temperature data.

The design of engineering structures and plant is frequently influenced by temperature conditions. Provision for ice control in reservoirs and canals is necessary in a region where freezing temperatures prevail. Highway subgrades must also be protected from frost heave by adequate drainage, and concrete structures which withstand water pressure must be made of sufficient thickness and density to prevent spalling off of the face by the freezing of water in the interstices of the material. Provision for artificial heating in buildings and temperature control in steam power plants is also dependent upon knowledge of air temperature.

Large outdoor construction operations are vitally influenced by temperature. Quarters for men engaged upon the work must be provided which will mitigate as far as possible the extremes of heat and cold. Transportation must be planned which will not be disrupted by cold weather. Provision for hot water as a feature of concrete mixing plant must be made if air temperature falls below freezing for any length of time, and also protection at night for each day's fresh pour. Temperature conditions are also of importance in selecting locations for construction plants and camps as well as the more permanent locations for industrial plants or communities. As an example of the latter, the choice of location for Boulder City, made by the engineers of the United States Reclamation Service, was largely based on temperature conditions.

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Temperature is the most important factor controlling evaporation during an extended period of time, such as a month or a year. Air temperature is frequently studied by hydraulic engineers in the absence of direct observations to determine the approximate evaporation from proposed reservoir surfaces.

### WIND

Information regarding wind movement is probably as much sought after by engineers as temperature. Direction, velocity, and pressure against high buildings are all desired. Wind direction has an important bearing on the layout of buildings and grounds, and especially upon plant location where offensive odors, smoke, dust, or fumes are produced. Sewage treatment, garbage treatment, and various industrial plants such as smelters, cement plants, etc., must all be carefully located with respect to prevailing winds so as not to create nuisance in established communities. Floating solids on lakes and reservoirs and dust and flies in the air are all carried by the wind.

Knowledge of wind velocity is often of importance in planning construction operations. For example, work on bodies of inland water which requires floating equipment, may encounter considerable interruption by reason of seasonal or periodic daily winds of velocity great enough to produce waves. Wind velocity is also of importance in studying short time variations in evaporation rate from reservoirs and the fluctuations in level of lakes. The greatest use which engineers make of wind velocity data is in connection with building design. Among the other forces which may act upon isolated buildings are those induced by wind. Partial failures of large modern buildings have occurred during heavy winds, as at Miami, Fla., during the hurricane of several years ago, and for buildings of lighter construction it is necessary to provide against wind forces of much lesser degree. Wind velocities are observed at all regular Wheather Bureau stations and published as average hourly wind movement for each month. These are of little value to the designing engineer, however, since wind movement is very irregular, and it is maximum velocities which do the damage. The printed recording anemometer sheets are of much greater value. These must be consulted for considerable periods of time in order to determine the relative probability of maximum winds of various intensities. If photostat negatives of these records were kept in local Weather Bureau offices it would increase the usefulness of such data.

There is great difference in wind velocity at differing heights above the surface of the ground. There is no standard height for Weather Bureau anemometers and no information published relative to surroundings or height at any station. It thus is necessary to study at first hand the environment of equipment at wind velocity stations in order to properly use the records. It would be of considerable value to have such information in published form, illurtrated by sketches or photographs. The exposure on the tops of tall buildings, which is quite common, is not always productive of a true wind record, and it is to be hoped that it may sometime become possible to place anemometers on skeleton towers such as radio towers, where they will be free from eddies and cross currents. Such a location would also be ideal for determining the effect of differing elevation upon wind velocity.

The conversion of wind velocities into wind pressures is a step which, although possibly not a meteorological problem, is yet of greatest importance to the engineer and one about which very little is known. The erection of large and costly structures in areas of high wind velocity is now causing concern to the designing engineer, and there is great need of scientific investigation of this subject. Such pressures vary greatly, not only with wind velocity but with shape and area of the exposed surface.

### EVAPORATION

This is a meteorological process of greatest interest to the engineer as it represents an important loss of water after the latter has been reduced to possession in a reservoir or canal system. All water supply estimates must take it into consideration, and it frequently influences the operation program of water systems. Evaporation rates from free water surfaces differ greatly depending upon the temperature, humidity, and movement of the air, the temperature of the water, and the area of the water surface. The engineer usually desires to know the daily, monthly, and annual rate from a large water surface such as a lake or reservoir. It has been found by experiment that the evaporation from small pans set on or even in the ground, does not reproduce conditions on the surface of a large water body. The nearest approach to reproduction of actual conditions with a small pan is when submerged and floating upon the surface of a large body of water, with water level at the same elevation both inside and outside the pan, and side walls of the pan not projecting far above the water level. Such a pan 3 feet square or circular, protected more or less from wave splash, is frequently installed by engineers. For a land pan set into the soil it has been found that the diameter must be at least 12 feet before conditions closely approach those of a large water surface.

The standard Weather Bureau pan is 4 feet in diameter and set on a platform slightly above the ground surface with free air circulation beneath. Observations from such a pan have been of little value to engineers until very recently when intensive investigations were made with pans of different sizes, shapes, and exposures, to develop the general principles involved. Most of this experimental work has been done by the Division of of Agricultural Engineering, United States Department of Agriculture, in the vicinity of Denver, Colo., although it is understood that similar work is in progress in California. The data thus far available indicate that a factor of 0.70 applied to the evaporation as observed in standard Weather Bureau pans, will indicate approximately the loss from a large water surface exposed to similar atmospheric conditions. This factor, although possibly subject to modification under conditions differing from those at Denver, as for example, relative day and night temperatures, now enables the engineer to utilize Weather Bureau evaporation data. Recent studies made by the writer in the San Francisco Bay region, where there have been six records kept at various times with widely differing pan equipment and exposure and including one Weather Bureau pan, showed that all observations could be reduced to reasonable agreement when corrected for differences of temperatures and pans.

### OTHER DATA

The four classes of observational data made available by the Weather Bureau, as discussed above, are the principal ones used by engineers. There is frequent use of other data, such as relative humidity, barometric pressure, sunlight hours, killing frosts, and especially the current weather forecasts. The latter are of frequent use in planning field work, construction operations, transportation of material, and the operation of reservoirs and canals. Most hydraulic engineers make it a daily practice to examine the weather map and speculate as to the probability of rain or snow within the next day or two. The long continued series of dry years through which we have been passing may have had its influence in forming this habit, although the use of reports from vessels on the Pacific Ocean in making forecasts has greatly stimulated it.

All governmental bureaus must of necessity carry on their work under definite financial appropriations or budget allowances, and in accordance with fiscal and departmental rules and regulations. These are restrictions which more or less limit any organization, whether governmental or private, but must be especially rigid in the governmental service. The United States Weather Bureau, being one of the older scientific bureaus of our Government, is possibly more burdened with these restrictions than some of the more recently organized services. Regardless of such handicap, however, the work of the Weather Bureau is touching an ever-increasing number of people and serving a widening variety of interests.

The usual purpose for the creation of permanent governmental agencies engaged in scientific work is to meet some direct need either of the people or of government acting in the interest of the people. Once organized, with an established administrative routine, the original purpose is sometimes lost sight of either by a failure to keep pace with the changing needs of the people for current information of a scientific character, by a lack of vision and energy in undertaking fundamental research, or by inadequate facilities for making the data available. Although this tendency has at times been noticeable in governmental bureaus of the United States, it has never reached such extremes as have been witnessed in certain older countries where the ideal of government being for the benefit of the people is not so generally recognized.

In the practice of his profession the writer has had contact with the meteorological departments of foreign governments as well as the United States, and has been impressed by the differences in objective. Our Weather Bureau is not administered as a background for the scientific interests of any official or organization, nor to meet the specific requirements of some other branch of the Government service to the exclusion of the needs of the public. Its objective is to render promptly a wide variety of service to the extent which funds and departmental rules and regulations will permit, and in so doing it is filling a real need. Many engineers would like to see broader scope or refinement in certain phases of its meteorological work, but it should be remembered that in the final analysis the burden of improvement and enlargement can not be carried by bureau officials alone. It must be participated in by public spirited citizens working through the various channels which create and make effective public opinion.

# FLORIDA HURRICANES

By RICHARD W. GRAY

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During the 45-year period ending with 1930, 46 tropical cyclones either moved inland over Florida, or passed near enough to cause damaging winds in the coastal regions of the State. Of the 46 storms, 37 were of known hurricane intensity, while nine were less than hurricane intensity, or doubtful as to hurricane intensity. Table 1 shows that these storms have been fairly well distributed throughout the 45-year period, although a greater number occurred during the 5-year period, 1924–1928, than during any other period of similar length. The greatest number of consecutive years without tropical storms was two.

Although there is an average of one tropical storm a year for Florida as a whole, the average for any given part of the State is greatly less than this; and there is a marked difference in the number of storms that have occurred in the different parts of the State. Charles L. Mitchell (1) has shown that the average interval between tropical storms of hurricane intensity on the east coast of Florida, for each hundred-mile section of coast line, is 20 years, while the average interval between storms on the west Florida coast, for the same unit of coast line, is 13.9 years. The shorter interval on the west coast is due to the relatively great number of storms that have occurred between Cedar Keys, Fla., and Mobile, Ala. Only five tropical storms of hurricane intensity in the last 45 years have passed inland over the west coast of the peninsula between Fort Myers and Cedar Keys. Tampa is located in this section of the coastal region, and it has been more nearly exempt from hurricanes than any other coast city in southern Florida.

TABLE 1.—*Frequency of tropical cyclones by years*

| Year | Of known hurricane intensity | Doubtful as to hurricane intensity | Total | Year | Of known hurricane intensity | Doubtful as to hurricane intensity | Total |
|---|---|---|---|---|---|---|---|
| 1886 | 0 | 0 | 0 | 1911 | 1 | 0 | 1 |
| 1887 | 1 | 0 | 1 | 1912 | 1 | 0 | 1 |
| 1888 | 3 | 0 | 3 | 1913 | 0 | 0 | 0 |
| 1889 | 0 | 1 | 1 | 1914 | 0 | 0 | 0 |
| 1890 | 0 | 0 | 0 | 1915 | 1 | 0 | 1 |
| 1891 | 1 | 2 | 3 | 1916 | 1 | 1 | 2 |
| 1892 | 0 | 0 | 0 | 1917 | 1 | 0 | 1 |
| 1893 | 0 | 2 | 2 | 1918 | 0 | 0 | 0 |
| 1894 | 2 | 0 | 2 | 1919 | 1 | 0 | 1 |
| 1895 | 2 | 0 | 2 | 1920 | 0 | 0 | 0 |
| 1896 | 2 | 0 | 2 | 1921 | 1 | 0 | 1 |
| 1897 | 0 | 1 | 1 | 1922 | 0 | 0 | 0 |
| 1898 | 0 | 1 | 1 | 1923 | 0 | 0 | 0 |
| 1899 | 1 | 0 | 1 | 1924 | 3 | 0 | 3 |
| 1900 | 0 | 0 | 0 | 1925 | 1 | 0 | 1 |
| 1901 | 1 | 0 | 1 | 1926 | 3 | 0 | 3 |
| 1902 | 1 | 0 | 1 | 1927 | 0 | 0 | 0 |
| 1903 | 1 | 0 | 1 | 1928 | 3 | 0 | 3 |
| 1904 | 0 | 0 | 0 | 1929 | 1 | 0 | 1 |
| 1905 | 0 | 0 | | 1930 | 0 | 0 | 0 |
| 1906 | 2 | 1 | 3 | Total | 37 | 9 | 46 |
| 1907 | 0 | 0 | 0 | | | | |
| 1908 | 0 | 0 | 0 | | | | |
| 1909 | 1 | 0 | 1 | | | | |
| 1910 | 1 | 0 | 1 | | | | |

Key West, on account of its exposed location in the Florida Straits, and Pensacola, on account of its exposed position to western Caribbean storms, have experienced more hurricanes than any other cities in the State. Key West has been in or near the paths of storms originating in both the Atlantic Ocean and the western Caribbean Sea, while all storms, but one, that passed inland over the west coast of the peninsula had their origin in western Caribbean waters. Several storms have recurved over western Cuba and struck the south coast, but all storms reaching the east coast from the Atlantic moved north of Cuba and through the Bahamas.

The northwestern Florida coast is especially exposed to the western Caribbean storms, and it has suffered from several hurricanes that moved through the Florida Straits out of the eastern Caribbean, or that crossed the Florida Peninsula and redeveloped great intensity after passing into the Gulf of Mexico. In this connection it should be said that all storms crossing the peninsula reach the opposite coast from which they entered with greatly decreased intensity. A notable example of a hurricane crossing the peninsula from the east and redeveloping great intensity over the Gulf was the Miami hurricane of September 18, 1926, which passed near Pensacola two days later, causing a wind velocity of 92 miles per hour. (Corrected to 3-cup scale.)

Contrary to popular belief, more hurricanes have occurred in Florida in October than in any other month, this in spite of the anomalous fact that no hurricane has passed inland over the east coast of Florida during October in the last 51 years. (1) All October storms have either struck the west or extreme south coasts, or have recurved to the northeastward off the lower east coast. The decided tendency for tropical cyclones to develop over the western Caribbean Sea near the end of the hurricane season is shown by the fact that, of 21 Florida storms that had their origin in the western Caribbean in the last 45 years, 12 occurred in October and two in November. One of these was the famous "loop" hurricane of October, 1910, that twice swept over Key West and Habana. (2).

The most belated tropical cyclone of record to reach the coast of the United States developed over the western Caribbean and moved northeastward through the Yucatan Channel to the extreme lower west coast of Florida, where it passed inland on November 30, 1925. It passed off the upper east coast of Florida on December 1. This storm was attended by winds of hurricane force on the extreme lower west coast and by excessive rains throughout the peninsula. A remarkable 24-hour rainfall of 15.10 inches occurred at Miami in connection with this storm.

The frequency of tropical cyclones by months for Florida is shown in Table 2. This table is based on the 45-year record ending with 1930.

TABLE 2.—*Frequency of tropical cyclones by months*

| | June | July | Aug. | Sept. | Oct. | Nov. | Total |
|---|---|---|---|---|---|---|---|
| Of known hurricane intensity | 2 | 3 | 7 | 13 | 11 | 1 | 37 |
| Doubtful as to hurricane intensity | 3 | 0 | 0 | 0 | 5 | 1 | 9 |
| Total | 5 | 3 | 7 | 13 | 16 | 2 | 46 |

A study of the chart of hurricane paths shows that tropical cyclones are most likely to occur on the east coast of Florida during the months of August and September, and on the west coast during October. The chances of a hurricane reaching the Florida coast in any given year are about one in four for the east coast and one in two for the west coast. It should be said, however, that these storms are much more likely to occur on the lower east coast, extreme lower west coast, and the northwest coast. The upper east coast section, in which Jacksonville is located, and the middle west coast section, in which Tampa and St. Petersburg are located, have been relatively free from hurricanes, and the chances of a hurricane occurring in those sections in any given year are very slight. Since the center of a hurricane, as a rule, must pass within 50 miles of a place to cause winds of hurricane force, the chances of hurricane winds occurring at any given place in any given year are considerably less than is indicated by the chart of hurricane paths. The chances of hurricane winds in any year for several of the important cities of the State are roughly indicated in Table 3.

TABLE 3.—*Chances of winds of hurricane force in any given year*

| City | Chances | City | Chances |
|---|---|---|---|
| Jacksonville | 1 in 50 | Fort Myers | 1 in 20 |
| West Palm Beach | 1 in 20 | Tampa | 1 in 30 |
| Miami | 1 in 20 | Pensacola | 1 in 10 |
| Key West | 1 in 10 | | |

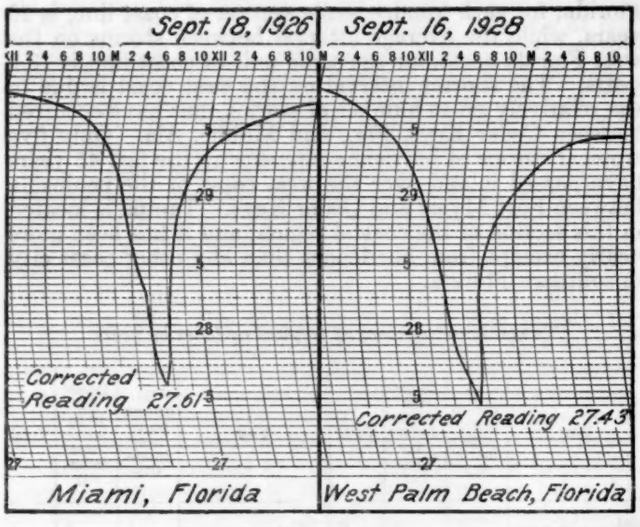
The occurrence of tornadoes in the northeast quadrant of a hurricane area was an interesting phenomenon observed in connection with the Florida hurricanes of September 10, 1919 (3), and September 28, 1929 (4). Both of these storms passed through the Florida Straits, and, when located off the extreme lower southwest coast, caused tornadoes along the lower east coast. In the case of the second storm, several tornadoes occurred from Miami northward to Stuart. These tornadoes all moved from the southeast to the northwest with the hurricane winds prevailing at the time, and the indications were that they developed over the ocean as waterspouts. Their paths extended only a few miles inland.

Of all the hurricanes that reached the Florida coast in the last 51 years, only eight can be classed as "great," both as to intensity and diameter (1). Several storms not so classed, however, were attended by destructive winds and loss of life. The "great" Florida hurricanes of the last 51 years were as follows:

June, 1886: Apalachicola-Tallahassee section.
July, 1916: Mobile-Pensacola section.
August, 1880: West Palm Beach-Lake Okeechobee section.
September, 1919: Key West section.
September, 1926: Miami-Lake Okeechobee-Pensacola sections.
September, 1928: West Palm Beach-Okechobee section.
October, 1910: Key West-Fort Myers section.
October, 1916: Mobile-Pensacola section.

The lowest sea-level barometer readings of record for the United States occurred in connection with the great Miami and West Palm Beach hurricanes of September 18, 1926, and of September 16, 1928. (See fig. 1.) While the barometer fell to 27.43 inches in the West Palm Beach hurricane, as compared with 27.61 inches in the Miami hurricane, it was evident from an inspection of the storm areas that a higher wind velocity occurred in the Miami storm. The trees left standing in the Miami area, even in the densest jungles, were completely defoliated, while many trees in the Palm Beach area, after the 1928 storm, were only partly defoliated. Apparently, the gradient in the West Palm Beach storm, which previously had caused a wind velocity of 160 miles per hour at San Juan, Puerto Rico, decreased before the disturbance reached the Florida coast. The diameter of the vortex of the Miami hurricane was 13 miles, while that of the West Palm Beach hurricane was approximately 25 miles. The highest recorded wind velocity for the United States, 138 miles per hour, by 3-cup anemometer registration, occurred at Miami Beach during the Miami hurricane (5). The much greater loss of life attending the West Palm Beach hurricane was not caused by the direct force of the wind, but by the flood waters from Lake Okeechobee.

A thorough inspection of the storm areas in the Miami and West Palm Beach hurricanes, which rank with the greatest of record in so far as wind velocity and loss of life and property are concerned, clearly indicates that hurricanes of major intensity do not cause serious structural damage to property constructed buildings. This statement does not apply to buildings near an ocean beach, where foundations may be undermined or the beach badly eroded by storm tides. Several substantial houses




near the ocean at Miami Beach were undermined and collapsed in the hurricane of September 18, 1926, but substantial buildings only one block from the ocean escaped serious structural damage. Practically all buildings were damaged by water, resulting from broken windows and doors, or from damaged roofs. In Miami there were several frame residences, with shingle roofs, which were erected when the city was first laid out, in 1896. These houses escaped, not only structural damage, but serious water damage, while many hundreds of concrete-block houses of flimsy construction were demolished. The same conditions were observed at Palm Beach, West Palm Beach, and Lake Worth, which were directly in the path of the September 16, 1928, hurricane. Office buildings of the better type, ranging in height from 10 to 20 stories, were damaged principally by water. There were a number of substantial residences that were seriously damaged by débris from other buildings or by falling trees, but, with these exceptions, the writer observed no substantially-constructed buildings in which the occupants were not safe during the entire duration of the

Miami and West Palm Beach hurricanes. In Key West, there are a considerable number of frame buildings that have withstood all the hurricanes of the last 50 years at that place without serious damage. One frame structure on the Government reservation has safely passed through all the Key West hurricanes since 1846.

Observations of the storm areas of the severe hurricanes on the east coast of Florida in 1926, 1928, and 1929 warrant the following statement.

If a building is properly constructed, including the proper type of roof and roofing material, and is securely anchored to the proper kind of foundation, it will not sustain serious structural damage in a hurricane of major intensity. If, in addition to the proper construction, all windows, doors, and vents are protected by storm shutters, the building should withstand strong hurricane winds with practically no damage. Such a building can be constructed at only a moderate increase of cost above that for the usual type of construction, and the saving in storm insurance will repay the extra cost in a few years time.

Grateful acknowledgment is made to Mr. B. K. Durst, who prepared two of the tables used in this paper.

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(NOTE.—No tropical storms of consequence passed over Florida during 1931 or 1932.—Editor).

# LAKE OKEECHOBEE AND SAFETY FROM TROPICAL STORMS

By A. J. MITCHELL

[Weather Bureau Office, Jacksonville, Fla.]

SYNOPSIS

This paper describes Lake Okeechobee as to area, depth, configuration, drainage area, and other features, particularly with reference to the hurricane disasters of 1926 and 1928.

Lake Okeechobee is in the south-central portion of the Florida peninsula; it is between 30 and 40 miles in diameter. The surface of the lake is between 700 and 800 square miles; its depth varies from a maximum of 15 feet to only a few inches at the outer circumference, especially on the south and west shores where the water is shallow. The configuration of the lake is nearly round, and its drainage area comprises 5,300 square miles. The Everglades, an area about 90 miles long and 40 miles wide, compose an area of 4,500 square miles; they are just to the south of the lake and over which shore (south) the flood waters of Lake Okeechobee found their exit to a large extent. It was to drain these glades that inspired the first efforts of Gov. N. B. Broward in seeking a platform in race for governor. Broward made the race on "Draining the Everglades," which platform carried him into the State's executive chair, and later to the very door of the United States Senate, but a cruel fate decreed that he should not enter; he died before he took his seat.

I have, thus, termed the Lake Okeechobee and Everglades project: An industrial baby, born of a political exigency.

Progress now being made to offset the dreadful incidents which have attended tropical storms in the Okeechobee region during the last few years should prove reassuring to many who have property and other interests in the Everglades district. The State of Florida and the Federal Government are constructing levees on and around the lake to the end that disasters such as those that attended the hurricanes of 1926 and 1928 shall not recur.

There has been so much apprehension in some circles regarding the safety of life and property on Lake Okeechobee, Fla., since the occurrence of the hurricanes of 1926 and 1928 that it seems wise to give publicity to the activities of the Federal Government and the State of Florida on the lake with the assurance that when the projects now under way shall be fait accompli there need be little concern with respect to the security of all interests on Lake Okeechobee and adjacent waters, regardless of the possible severity of tropical disturbances which, however, are by no means of annual occurrence.

Lake Okeechobee is between 30 and 40 miles in diameter, being the largest body of fresh water within the continental interior of the United States, exclusive of Lake Michigan which we do not consider as coming within the purview of this paper.

Geographically, the lake is in the south-central portion of the Florida peninsula. It is generally round, suggestive of a natural amphitheater, the depth varying from a maximum of about 15 feet to a gentle wind tide of a few inches near the outer rim of the lake, especially on the south and west shores. Latitude 26″ north and longitude 81° west bisect, so to speak, the center of the lake.

The geological history of the State indicates that Lake Okeechobee was much larger at one time, and that it fills an original depression in the floor of the sea which once covered the coastal terrace. Pleistocene and pliocene shells are seen on the spoils banks of the canals, and the shoal waters out from Moore Haven are underlain with pleistocene shells, marl, and limestone; thus giving some knowledge of the varying life phases of the peninsula, which appears to be quite ancient.

The water surface of Lake Okeechobee is between 700 and 800 square miles, and it has a drainage area, mostly to the north, comprising 5,300 square miles which represent in the aggregate the drainage areas of Taylors Creek, Fisheating Creek, and the Kissimmee River, the last named being the chief tributary, reaching to the northward 137 miles as measured by the course of the stream, but in reality less than 100 miles. The deepest water in the lake will not be more than 15 feet when the elevation of the water surface of the lake is 15 feet above mean low water at Punta Rassa on the Gulf of Mexico.

Immediately to the south of Lake Okeechobee are the Everglades, a low marshy area about 90 miles long and 40 miles wide, comprising 4,500 square miles. These lands slope toward the southern end of the Florida peninsula at the rate of 2 or 3 inches to the mile. Originally, the elevation of the Everglades bordering on the lake was 21 to 22 feet above mean low water of the Gulf of Mexico, but as a result of drainage operations the land has subsided to 17 and 19 feet above the mean low water of the Gulf. A large volume of the flood waters of the lake is or was discharged over its southern rim, and before the drainage work became effective the Everglades were covered by several feet of water. As evidence of the vagaries of lake stages its depth varying with the volume supplied by its tributaries, the deficiency in rainfall during the year 1931 has resulted in a decided contraction of the water line, and at this time one can walk dry shod about one mile nearer the lake's center; in fact, enterprising truck growers have

planted crops on land which was, normally, a part of the lake bottom.

The dwellers on Lake Okeechobee may have been cognizant of the fact that high water was possible under a concert of conditions, but the possibility of a disaster on this erstwhile tranquil lake had never been suggested.

Metaphorically, the hurricane is the monarch of the air; like a thing of life it marches with measured tread over land and sea; it grants no favors, but it exacts enormous tribute.

It was this knowledge and the coincidental occurrence of high water on Lake Okeechobee and the Miami hurricane of 1926 with the sequence of a major tragedy at Moore Haven and Miami, which brought to the attention of all concerned the necessity for greater protection to life and property against the almost irrestible powers of wind and water. It will be needless repetition to treat in extenso the hurricanes of September, 1926 and 1928, as the important meteorological data are known of all men, especially Weather Bureau men.

### STORM OF SEPTEMBER, 1926

The hurricane of September, 1926, approached the coast at Miami about 6:45 a. m. of the 18th, continuing northwestward to the south of Fort Myers, Fla., and across the Gulf to the south of Mobile; thence to the Mississippi coast, dissipating over Louisiana. The lowest barometer reading at Miami was 27.61 inches, as shown by the photostatic copy on the lower left of the chart; it was the lowest reading of record in this country, and it was close to the world record, 27.02 inches, during a typhoon in China, August, 1891. Hann is my authority for the latter value. As shown by the chart, the center of the storm was to the south of the lake, as hurricane winds from the northeast continued until the afternoon, breaking and topping the levees in the vicinity of Moore Haven and piling up water to an elevation of 29 feet, with resulting deaths and property loss in that district.

The water surface of Lake Okeechobee on August 26, 1926, was 18 feet above mean low water of the Gulf, and just before the hurricane of September 17–18 the surface of the lake was at elevation 19.2 feet, and for some time after the hurricane the elevation was 19.8 feet, the rise from 19.2 to 19.8 being due, no doubt, to the heavy rains during the storm among which the following, inches and tenths, are mentioned: Bradenton, 8.8; Fort Myers, 8.0; Hypoluxo, 5.6; Belle Glade, 4.3; Jupiter, 5.7; St. Petersburg, 6.5; Pinellas Park, 6.6; and Miami, 8.0, incomplete. The following amounts fell during the 19–20th over the northern and northwestern counties, as the center moved across the Gulf: Apalachicola, 4.5; St. Andrew, 7.7; Quincy, 6.2; Mount Pleasant, 6.5; Vernon, 6.5; Marianna, 6.3; Bonifay, 6.8; Pensacola, 8.6; Bluff Springs, 11.2; and Blountstown, 16.4 inches.

### STORM OF SEPTEMBER, 1928

The center of this storm passed over Palm Beach about 7:30 p. m. of September 16, thence to the south-central portion of the peninsula, the center bearing somewhat to the east and north, although the lake was well under the influence of the center, as the usual calm obtained. Hurricane winds prevailed from the north-northwest, becoming south-southwest as the center passed. The north-northwest winds piled up water, a severe storm wave, to an elevation of 29 feet in the pocket of the southern rim of the lake, which spelled the doom of 1,700 souls. The wind shift to the south-southwest, incident to the passing of the center, reversed the direction of the storm wave from the southern shores to the northern pocket of Taylors Creek where others were overwhelmed on those unhappy waters. The lowest barometer reading at Palm Beach was 27.45 inches, which was appreciably lower than during the Miami storm of 1926. The center of this storm moved to the northward within the peninsula, passing Jacksonville slightly to the westward during the early hours of September 18. The lowest barometer readings are shown on the photostatic copy attached to the chart on the lower right.

It was the high water together with the severe wave action that washed away much of the levees in the vicinity of Moore Haven during the storm of 1926, the same having been provided to protect, rather to prevent the lake overflow onto the Everglades; the levees were not constructed with the viewpoint of life protection, as the same, probably, had never received consideration from any source. This, however, is no criticism of those who directed activities on the lake, as their ability was unquestioned and their vision as to the occurrence of untoward events was as reliable as were the teachings of history relating to Lake Okeechobee and associated waters.

The storm tides were increased, no doubt, during both storms owing to the shallow water some distance from the shores on the south and west sides of the lake which greatly retarded the return of the subsurface flow. The bottom of the lake on the east shore slopes at a much steeper angle, thereby facilitating the subsurface flow which, probably, explains its freedom from the melancholy history of the lake, as written by the storms of 1926 and 1928.

A clear understanding of the objects to be accomplished by the State of Florida, as compared with the objective of the Federal Government in their respective activities on Lake Okeechobee, will prove reassuring.

The organic law of the State of Florida having to do with initiating work in the Everglades was to provide drainage, irrigation, and flood control of the lake; several million acres of land were to be reclaimed for agriculture and horticulture, expenditures along that line up to the present amounting to about $20,000,000.

In contrast with the State's mandate, the high purpose of the Federal Government is, primarily, to safeguard life and property, and, incidentally, improve commerce by the widening and deepening of channels, rivers, lakes, and canals.

At the time of the hurricane of September, 1926, the five canals, namely, the West Palm Beach, Hillsboro, North New River, Miami, and the St. Lucie had been completed, except that the St. Lucie Canal, which is the chief outlet for the lake, was not functioning to its capacity, which was 2,500 cubic feet per second. The State's drainage board decided that the discharge of the St. Lucie Canal should be doubled to regulate more effectively the lake stages. In that connection, however, the United States engineers in their report of April 2, 1928, on survey of Calloosahatchee River and Lake Okeechobee drainage, fail to concur with the State's drainage board as to their conclusions regarding amplified work to care for abnormal floods, or storm conditions on Lake Okeechobee. The United States engineers made the following report:

It should be clearly understood that neither the recommended increased capacities of outlet canals for the control of Lake Okeechobee nor further increase in outlet capacities within the bounds of reasonable expenditures would be sufficient to hold the water surface of Lake Okeechobee at the same level at all times. In other words, during the rainy season water accumulates in Lake Okeechobee very much faster than it can be taken out by any practical method.

With that definite declaration by the Federal engineers with respect to regulating the stages of Lake Okeechobee the river and harbor act, approved July 3, 1930,

Provided for the flood control of Lake Okeechobee and certain navigable channels leading from the lake to tide water on either side of the peninsula.

The comprehensive character of the project, now being aggressively advanced, is such as to dispel fear and restore confidence in the security of life and property on Lake Okeechobee, all vouchsafed by the integrity of the Federal Government. Both outlets of the lake, namely, the St. Lucie Canal and the Caloosahatchee River, become links in the chain of intracoastal waterways of the United States.

The magnitude of the project is apparent when it is stated that levees, dykes, locks, and other control measures will form a sort of arc of a circle, extending from Fisheating Creek on the southwest shore via Moore Haven, Clewiston, Belle Glade, Pahoka, and Port Mayaca (St. Lucie Canal) on the south, a distance of 63 miles. The standard design of the protection levees provides for a crest elevation of 34 feet above mean low water of the Gulf at Punta Rassa with a crest width of 15 feet, a most formidable and enduring arm of safety.

And as a supplementary agency to regulate the lake stage, the discharge output of the St. Lucie Canal, which is now 5,000 cubic feet per second, is available should any emergency arise.

To combat all danger of floods over the northern shore of the lake, that is the Taylors Creek section, a system of levees similar to that provided for the southern shores will be constructed along the shore from the mouth of the Kissimmee River to and past Taylors Creek, a distance of 24 miles with levees on each side of the creek leading up to Okeechobee City. And there is or will be further safety through the discharge of 2,500 cubic feet per second through the Caloosahatchee Canal from Lake Okeechobee to Fort Thompson, a distance of 23 miles.

The following are coordinate parts of the Lake Okeechobee project:

(*a*) Provide a channel 200 feet wide and 12 feet deep from the Gulf to Punta Rassa.

(*b*) A channel 100 feet wide and 10 feet deep from Punta Rosa to Fort Myers.

(*c*) A channel 80 feet wide and 6 feet deep, Fort Myers to Lake Okeechobee, thence through the lake a channel 6 feet deep and 80 feet wide to the St. Lucie Canal. This canal has a minimum depth of 8 feet and a bottom width of from 150 feet to 165 feet.

The completion of the Lake Okeechobee system in its entirety sustains a relationship to the intracoastal waterways of the United States that is much more than simply a chain or link in that system which, it is conceded, might become an important factor in the communication system of the country during periods of national stress. Then Lake Okeechobee and its associated waterways would become an avenue of ingress and egress for the Gulf of Mexico and the Atlantic Ocean, really an arm of offense and defense of the Navy, making possible a rapid shift from the Gulf to the Atlantic of such forces as might be necessary to meet unexpected attacks, or to make possible a quick offense by the smaller units of the United States Navy.

## THE RELATIVE DISTRIBUTION OF EARLY AND LATE SEASONAL RAINFALL IN SOUTHERN CALIFORNIA

By CHARLES C. CONROY

In view of popular and journalistic speculation as to the probability of late rains when early ones have been abundant, and because of the widespread interest in the subject of seasonal precipitation in Southern California, the writer has undertaken to analyze the relative distribution of early and late rainfall in that region. The analysis covers the period from July 1, 1877, to June 30, 1927—50 seasons—and is based upon the records, grouped by decades, of the two regular weather bureau stations—Los Angeles and San Diego. The results are tabulated below. In the tables, column (*a*) shows the total rainfall by decades and for the period; column (*b*) the corresponding early rainfall; column (*c*) its percentage of the decadal and total rainfall; column (*d*) the corresponding late rainfall; column (*e*) its percentage of the decadal and total fall for the period, and column (*f*) the percentage of the total fall represented by the midseasonal rains. The word "early" is used to designate the five months from July 1 to December 1; the word "late" the three months from April 1 to July 1. The expression "mid-seasonal" comprises the months of December, January, February, and March. In the "early" part of the rain year July and August have contributed only an inappreciable amount to the totals, so the early period is really strictly comparable, in length, with the "late" months of April, May, and June.

**Los Angeles**

| | (*a*) | (*b*) | (*c*) | (*d*) | (*e*) | (*f*) |
|---|---|---|---|---|---|---|
| | *Inches* | *Inches* | *Per cent* | *Inches* | *Per cent* | *Per cent* |
| 1877-87 | 172.34 | 19.88 | 11.5 | 27.35 | 15.8 | 72.7 |
| 1887-97 | 167.69 | 25.51 | 15.2 | 7.08 | 4.2 | 80.6 |
| 1897-07 | 132.96 | 22.47 | 16.1 | 15.34 | 11.5 | 72.4 |
| 1907-17 | 160.31 | 17.54 | 10.9 | 7.65 | 4.8 | 84.3 |
| 1917-27 | 127.79 | 17.67 | 13.8 | 21.26 | 16.7 | 69.5 |
| Sums | 761.39 | 103.07 | | 78.68 | | |
| Means | 152.28 | 20.61 | 13.5 | 15.74 | 10.6 | 75.9 |

**San Diego**

| | | | | | | |
|---|---|---|---|---|---|---|
| 1877-87 | 122.35 | 13.07 | 10.7 | 17.45 | 17.4 | 71.9 |
| 1887-97 | 99.15 | 13.94 | 14.1 | 5.26 | 5.3 | 80.6 |
| 1897-07 | 88.60 | 12.98 | 14.6 | 12.42 | 12.4 | 73.0 |
| 1907-17 | 106.20 | 16.55 | 15.6 | 7.33 | 7.3 | 77.1 |
| 1917-27 | 99.65 | 15.19 | 15.2 | 14.34 | 14.4 | 70.4 |
| Sums | 515.95 | 71.73 | | 56.80 | | |
| Means | 103.19 | 14.35 | 14.0 | 11.34 | 11.4 | 74.6 |

The outstanding features of the two tables are (1) the comparative constancy of the early (*c*) and mid-seasonal (*f*) rainfall as expressed in percentages of the whole; and (2) the wide variability and consequent uncertainty of the late rainfall, both in actual amounts (*d*) and in percentages, (*e*). In both Los Angeles and San Diego the departures from the mean are far larger in the late rain-

fall than in the early, and we may add that the records of the two stations are in close agreement in percentages throughout the 50-year period under discussion.

It is accordingly evident that pressure conditions conducive to rainfall in Southern California are more reliable factors in the autumn than in the spring. The tracks followed by disturbances moving eastward over the coast have in general a more southerly tendency in the autumn, and especially in November. Besides, "lows" which make their way into the Pacific Southwest from Mexico are more frequent in the fall months. Another occasional rainfall factor is the summer "low" over the lower Colorado River valley. This often persists, albeit somewhat weakened, throughout October, and the cooling of the air in the near-by coastal region occasionally operates with this "low" to produce considerable October rains.

On the other hand, the development of secondary "lows" over Nevada occurs more frequently in the spring than in the fall. Nevertheless, these depressions are uncertain causative factors in Southern California's late seasonal rainfall. If the barometric gradient between their centers and the coast is fairly large, it often happens that brisk to strong westerly or northwesterly winds are the only appreciable results of their development. Still, the coastal region sometimes receives a good rainfall from them, and we note that the greater relative frequency of thunderstorms in the Los Angeles area in the spring months is due to the barometric "lag" which remains for a day or two over the Tehachapi Mountains after their centers have moved eastward. In the long run, however, the tables show that rain producing conditions are decidedly more effective in the autumn months.

The direct movement of energetic depressions from the Pacific over or just north of Southern California is infrequent before December or after March. Occasionally, however, this occurs, and the results are seen in the excessive rainfalls of October, 1889, November, 1900, April, 1926, May, 1921, and June, 1884. These exceptional storms are, of course, included in the tabular values given above, but their amounts balance in the fall and spring totals so well that they do not sensibly affect the order of the several absolute and relative values.

Some interest may be taken in a comparison of the 50-year results for Southern California with those of two stations farther north: San Francisco and Sacramento. The following data are for the same period, and the columnar values have the same significance, as the corresponding ones in the southern tables:

San Francisco

| | (a) | (b) | (c) | (d) | (e) | (f) |
|---|---|---|---|---|---|---|
| | *Inches* | *Inches* | *Per cent* | *Inches* | *Per cent* | *Per cent* |
| 1877–87 | 254.97 | 41.60 | 16.3 | 46.74 | 18.3 | 65.4 |
| 1887–97 | 233.16 | 41.66 | 17.9 | 25.72 | 11.0 | 71.1 |
| 1897–07 | 193.78 | 43.29 | 22.3 | 20.27 | 11.5 | 66.2 |
| 1907–17 | 213.87 | 25.97 | 12.1 | 13.30 | 6.2 | 81.7 |
| 1917–27 | 201.37 | 42.10 | 20.9 | 23.42 | 11.6 | 67.4 |
| Sums | 1,097.15 | 194.62 | | 129.45 | | |
| Means | 219.43 | 38.92 | 17.9 | 25.89 | 11.7 | 70.4 |

Sacramento

| | | | | | | |
|---|---|---|---|---|---|---|
| 1877–87 | 209.71 | 32.70 | 15.7 | 31.50 | 15.2 | 69.1 |
| 1887–97 | 201.26 | 36.84 | 18.3 | 26.65 | 13.2 | 68.5 |
| 1897–07 | 186.71 | 39.82 | 21.3 | 23.04 | 12.3 | 66.4 |
| 1907–17 | 154.60 | 17.55 | 11.4 | 11.92 | 7.7 | 80.9 |
| 1917–27 | 142.85 | 33.99 | 23.8 | 18.65 | 13.1 | 63.3 |
| Sums | 903.33 | 160.90 | | 111.76 | | |
| Means | 180.66 | 32.18 | 18.1 | 24.37 | 12.3 | 69.6 |

It will be remarked that the early rainfall in these tables is remarkably uniform, in actual quantity, in four of the five 10-year periods, and that, in the decade in which it is deficient, an even larger proportional deficiency is found in the season of late rains also. In this particular decade—1907–1917—there is, therefore, an abnormally high relative value for the mid-seasonal rains. But, leaving this decade out of consideration, the others fail to show in the quantity of their late rains the uniformity which is characteristic of their earlier rains. On the whole, however, the irregularities from decade to decade are not so striking as they are in the southern tables, and this because the influence of northern "lows" is much more pronounced, and that of secondary "lows" over southern Nevada much less pronounced, than in the south.

On the other hand, in autumn the centers of nearly all important depressions move over the coast north of the central California stations. The prevailing winds during their passage are from southerly quadrants, and the rainfall in consequence is quite uniform from decade to decade. We find, therefore, that at all four stations the autumnal rainfall régime is similar, whilst in the vernal one considerable differences are introduced between north and south by the occasional development of depressions east or northeast of southern California. The presence or absence of these means a larger proportional element of variability in the southern spring.

While this method of statistical treatment does not afford good indications of the probability of early or late rains in any given year, it is nevertheless a fair indicator of the distribution of these rains in a group of years. In other words, it is a generalized analysis, useful in a broad sense.

## SEVERE SAND STORM IN EASTERN WYOMING, JANUARY 18, 1933

By F. L. DISTERDICK

[Weather Bureau office, Cheyenne, Wyo.]

Strong winds are of frequent occurrence over the plains section of Wyoming, but owing to the scarcity there of populous areas their occurrence seldom is noticed. On January 18, 1933, however, a wind and dust storm occurred that was so exceptionally severe that it attracted much attention.

On the morning of this date a cyclone was centered at Lander where the barometer (reduced) read 29.24 inches. The State forecast warned of strong shifting gales. The State highway commission was notified and the usual precaution was taken of stationing sentinels on all highways leaving Cheyenne to warn travelers. The winds of the forenoon ranged from 26 to 30 miles per hour and the storm center apparently moved directly eastward with increasing intensity, and passed out of the State near noon, close to the South Dakota-Nebraska boundary. At Cheyenne the true wind velocity was 65 miles per hour, 2 miles greater than the highest velocity previously recorded. Shortly before noon there was a sudden drop in the barometer soon followed by a decided increase in the wind velocity which for the next five hours was 52, 55, 54, 52, and 46 miles per hour, respectively. For three

hours thereafter the wind was comparatively light, but from 8 o'clock till midnight the hourly movement exceeded 40 miles.

The greatest damage occurred in the vicinity of Cheyenne, principally to roofs, chimneys, spouting, window glass, small garages, street signs and wires. At Fort Frances E. Warren the damage exceeded $12,000 and in Cheyenne more than $10,000. In the immediate vicinity of Cheyenne the damage to buildings amounted to about $3,000. In the rest of the State the damage is placed at $20,000 to $40,000.

For more than a month prior to this storm there had been very little precipitation and the wind, being abnormally high, had removed moisture from the soil to a considerable depth. Hence, in addition to the wind damage, there occurred also the most severe dust storm ever known to this part of the country. The small particles of the soil, consisting largely of decomposed granite, were caught up and some of it carried to great heights. The air near the surface was so completely filled with the sand that at times objects were invisible beyond 50 feet and headlights were used on automobiles. The larger particles, up to the size of walnuts, sent bouncing along the ground, caused large stock, some of which was injured, to stampede to shelter. Sheep could not stand up in the gale. The surfacing was removed from gravel roads and streets to the foundation. The soil in many plowed fields, in cases a foot deep, was removed to the gravel. Large windrows of sand were formed and many ditches filled. Great damage occurred to winter grain; much was blown out or covered with sand. Alfalfa also suffered in a similar manner. It is stated that the per cent of abandoned winter grain will be the greatest ever known in the State.

In some cases the sand blast stripped every particle of paint from the exposed parts of automobiles and so pitted the glass that not a piece could be seen through. All insulated objects became amazingly charged electrically. The ignition systems of automobiles were completely disrupted and hundreds of cars were stranded. The city engineer of Cheyenne states that the induced current was sufficient to start small electric motors. The anemometer pole at the city office became so charged that the triple register could not be touched without receiving a severe shock and it was necessary to ground the instrument.

## UNUSUAL LUNAR HALOS

M. R. Hovde, assistant meteorologist, and Mac A. Emerson, senior observer, St. Paul, Minn., noted at 11:30 p. m., Februray 7, 1933, the halo of 22°, complete; the halo of 46°, large arc; and the paraselenic circle, complete.

Harry V. Myers, observer, Moline, Ill., noted at 5 a. m., February 8, 1933, both paraselenae of 22°; the 22° halo, a portion of the 46° halo, the circumzenithal halo, a portion of the paraselenic circle, the moon pillar, and a cross through the moon.

C. G. Andrus, meteorologist, Cleveland, Ohio, recorded at 6:45 p. m., February 8, 1933, both paraselenae of 22°; the halo of 22°; the upper tangent arc of the halo of 22°; the upper portion of the halo of 46°; the circumzenithal circle; half of the paraselenic circle; a lunar pillar, vertical through the moon, and a cross, produced by the lunar pillar and the adjacent portions of the paraselenic circle.

J. H. Spencer, senior meteorologist, and A. P. Keller, junior meteorologist, Buffalo, N. Y., observed from 8 p. m., February 8, 1933, to after midnight (brightest from 9:30 p. m. to 10:30 p. m.) the halo of 22°; the paraselenic circle, complete; and a portion of the halo of 46°.

NOTE.—On these dates the moon was nearly full, that is, at about its brightest, and the halo-producing cirrus so thin that the brighter stars were clearly visible through it. In short, both the moon and the cirrus haze were in their optiumum states for producing visible halos. Similar solar halos were observed on this date, February 8, by Joseph J. Eigenmann, assistant observer, at Springfield, Ill., by Berlin Pugh, at Royal Center, Ind., and, doubtless, by many others. Evidently, therefore, the thin cloud that produced these solar and lunar halos was both extensive and persistent.—EDITOR.

## THE DUST STORM OF JANUARY 22, 1933, OVER SECTIONS OF ILLINOIS, INDIANA, AND MICHIGAN

By C. G. ANDRUS

[Weather Bureau Airport Station, Cleveland, Ohio]

On January 22, 1933, a rather well-defined dust storm that began and ended abruptly was reported by aviators and observers in sections of Illinois, Indiana, and Michigan. At some stations the visibility was reduced to less than 1 mile, causing a real hazard to flight. An aviator on passing through sudden dashes of rain about 3 p. m. on this date, in the northwestern corner of Ohio, found his windshield streaked with reddish-yellow "mud." The rain he encountered farther east was clear. On the next day, according to the Canadian press, about an inch of gravish-yellow snow fell at Chicoutimi, in Quebec.

This dust presumably was caught up in the dry southeastern sector of a low centered, at 8 p. m., January 21, in middle Kansas.

## SOLAR HALO, DECEMBER 14, 1932, AT MOORHEAD, MINN.

Mr. C. A. Olsen, junior observer at Moorhead, Minn., reports an interesting solar halo complex observed at that station on December 14, 1932. This consisted of (1) both the parhelia of 22°, (2) both the parehlia of 46°, (3) both the parhelia of 120°, (4) a short section of the parehlic arc through each parhelion of 120°, (5) the anthelion, (6) a short section of one or more of the anthelic arcs, (7) the parhelic circle, complete, (8) a sun pillar, vertical through the sun, (9) a cross (combination of pillar and adjacent portions of the parhelic circle, (10) the halo of 22°, (11) the upper tangent arc of the halo of 22°, (12) the halo of 46°, (13) the circumzenithal arc very brilliant over 20° to 30° on side nearest the sun; faint over the rest of the circle, but complete all the way around.

NOTE.—It is unusual, but not unknown, for the circumzenithal arc and Kern's arc (the arc farthest from the sun on the same circle as the circumzenithal arc) to blend into a complete circle.—EDITOR.

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# SOLAR OBSERVATIONS

## SOLAR RADIATION MEASUREMENTS DURING JANUARY, 1933

By IRVING F. HAND, Assistant in Solar Radiation Investigations

For a description of instruments employed and their exposures, the reader is referred to the January, 1932, REVIEW, page 26.

Table 1 shows that solar radiation intensities averaged above normal for January at Washington and Madison, and slightly below at Lincoln.

Table 2 shows an excess over the normal in the total solar radiation received on a horizontal surface at the larger cities of Washington, Lincoln, Chicago, New York, and Pittsburgh, and a deficiency at all other stations.

Table 3 shows slightly greater values of the turbidity factor, $\beta$, than in December.

Polarization observations made at Washington on four days give a mean of 58 per cent with a maximum of 64 per cent on the 30th. These are about normal values for the month. No measurements were made at Madison due to the presence of ice and snow.

TABLE 1.—*Solar-radiation intensities during January, 1933*

[Gram-calories per minute per square centimeter of normal surface]

**Washington, D. C.**

| Date | Sun's zenith distance: 8 a. m. | 78.7° | 75.7° | 70.7° | 60.0° | 0.0° | 60.0° | 70.7° | 75.7° | 78.7° | Noon |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 75th mer. time | Air mass: A. M. | | | | | P. M. | | | | Local mean solar time |
| | e. | 5.0 | 4.0 | 3.0 | 2.0 | *1.0 | 2.0 | 3.0 | 4.0 | 5.0 | e. |
| | *mm.* | *cal.* | *cal.* | *cal.* | *cal.* | *cal.* | *cal.* | *cal.* | *cal.* | *cal.* | *mm.* |
| Jan. 6 | 3.99 | 0.83 | 0.99 | 1.10 | 1.39 | | | 1.24 | | | 2.26 |
| Jan. 10 | 3.00 | .84 | .89 | 1.09 | 1.26 | | | | | | 3.81 |
| Jan. 16 | 3.63 | | | | 1.26 | | | | | | 3.81 |
| Jan. 20 | 3.00 | .92 | 1.02 | 1.19 | 1.40 | | | | | | 1.78 |
| Jan. 23 | 7.29 | | | | 1.05 | | | | | | 5.56 |
| Jan. 24 | 4.75 | | | | 1.24 | | 1.29 | | | | 3.15 |
| Jan. 30 | 2.36 | .91 | 1.08 | 1.18 | 1.32 | | | | | | 2.16 |
| Jan. 31 | 3.63 | .75 | .89 | 1.03 | 1.22 | | | | | | 4.57 |
| Means | | .85 | .97 | 1.12 | 1.27 | | (1.29) | (1.24) | | | |
| Departures | | +.11 | +.12 | +.10 | +.04 | | +.06 | +.20 | | | |
| **Madison, Wis.** | | | | | | | | | | | |
| Jan. 5 | 2.74 | | | | | | | 1.06 | | | 3.45 |
| Jan. 23 | 3.30 | | 1.12 | 1.26 | 1.38 | | | 1.07 | | | 3.15 |
| Means | | | (1.12) | (1.26) | (1.38) | | | (1.06) | | | |
| Departures | | | +.08 | +.06 | +.05 | | | −.09 | | | |

TABLE 1.—*Solar-radiation intensities during January, 1933*—Con.

[Gram-calories per minute per square centimeter of normal surface]

**Lincoln, Nebr.**

| Date | Sun's zenith distance: 8 a. m. | 78.7° | 75.7° | 70.7° | 60.0° | 0.0° | 60.0° | 70.7° | 75.7° | 78.7° | Noon |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 75th mer. time | Air mass: A. M. | | | | | P. M. | | | | Local mean solar time |
| | e. | 5.0 | 4.0 | 3.0 | 2.0 | *1.0 | 2.0 | 3.0 | 4.0 | 5.0 | e. |
| | *mm.* | *cal.* | *cal.* | *cal.* | *cal.* | *cal.* | *cal.* | *cal.* | *cal.* | *cal.* | *mm.* |
| Jan. 3 | 3.15 | | | | | | | 1.17 | | | 3.81 |
| Jan. 5 | 3.30 | | | | | | | 1.04 | | | 3.63 |
| Jan. 7 | 2.87 | .93 | .98 | 1.21 | | | | | | | 3.15 |
| Jan. 9 | 2.87 | .94 | 1.08 | 1.21 | | | | | | | 4.57 |
| Jan. 19 | 3.15 | .99 | 1.12 | 1.27 | | | | | | | 2.49 |
| Jan. 22 | 5.16 | .99 | 1.12 | 1.25 | | | | | | | 4.17 |
| Jan. 23 | 3.30 | | .89 | 1.14 | | | | 1.15 | .95 | .89 | 3.99 |
| Jan. 25 | 2.87 | | .92 | 1.12 | 1.37 | | | 1.21 | 1.06 | .93 | 3.30 |
| Jan. 27 | 2.36 | 1.01 | 1.13 | 1.28 | | | | | | | 2.62 |
| Means | | .95 | 1.03 | 1.21 | (1.37) | | | 1.14 | (1.00) | (.91) | |
| Departures | | +.01 | −.02 | +.03 | | | | −.03 | −.04 | −.02 | |

*Extrapolated.

TABLE 2.—*Average daily totals of solar radiation (direct+diffuse) received on a horizontal surface*

| Week beginning— | Washington | Madison | Lincoln | Chicago | New York | Fresno | Pittsburgh | Fairbanks | Twin Falls | La Jolla | Gainesville | Miami | New Orleans |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Gram calories per square centimeter | | | | | | | | | | | | |
| 1933 | *Cal.* | *Cal.* | *Cal.* | *Cal.* | *Cal.* | *Cal.* | *Cal.* | *Cal.* | *Cal.* | *Cal.* | *Cal.* | *Cal.* | *Cal.* |
| Jan. 1 | 214 | 145 | 215 | 144 | 156 | 101 | 134 | 7.0 | 163 | 242 | 103 | 251 | 172 |
| Jan. 8 | 155 | 137 | 192 | 147 | 127 | 168 | 119 | 7.7 | 170 | 246 | 65 | 251 | 144 |
| Jan. 15 | 182 | 126 | 162 | 116 | 155 | 124 | 132 | 7.5 | 144 | 162 | 185 | 266 | 208 |
| Jan. 22 | 160 | 115 | 235 | 70 | 141 | 197 | 67 | 16.6 | 161 | 204 | 168 | 332 | 158 |
| | Departures from weekly normals | | | | | | | | | | | | |
| Jan. 1 | +60 | +13 | +29 | +60 | +50 | −45 | +30 | ---------- | −5 | +6 | −119 | −37 | ---------- |
| Jan. 8 | +2 | −3 | +3 | +60 | +21 | +11 | +16 | ---------- | −11 | +13 | −144 | −34 | ---------- |
| Jan. 15 | +19 | −32 | −36 | +20 | +39 | −58 | +25 | ---------- | −46 | −71 | −13 | −23 | ---------- |
| Jan. 22 | −17 | −68 | +12 | −38 | +7 | −9 | −42 | ---------- | −27 | −43 | −51 | +9 | ---------- |
| | Accumulated departures on January 28 | | | | | | | | | | | | |
| | +448 | −630 | +56 | +714 | +819 | −707 | +203 | ---------- | −623 | −665 | −2,289 | −595 | ---------- |

TABLE 3.—*Solar radiation measurements, and determinations of atmospheric factor, β, Washington, D. C., January, 1933*

[Values in italics have been interpolated]

| Date and solar hour angle | Solar altitude, h. | Air mass, m. | $I_m$ | $I_y$ | $I_r$ | β | Blueness of sky | Atmospheric dust particles per cubic centimeter | Notes: Skylight polarization, P., clouds, etc. |
|---|---|---|---|---|---|---|---|---|---|
| 1933 Jan. 6 | | | *gr. cal.* | *gr. cal.* | *gr. cal.* | | | | |
| 3:23 a | 12–23 | 4.59 | 0.896 | 0.717 | *0.622* | 0.055 | | 499 | |
| 3:18 a | 13–06 | 4.34 | .931 | *.720* | .627 | .055 | | | |
| 2:51 a | 16–43 | 3.45 | 1.041 | *.845* | .681 | .055 | | | |
| 2:45 a | 17–28 | 3.30 | 1.064 | .846 | *.706* | .075 | | | |
| 2:42 a | 17–50 | 3.24 | 1.069 | *.871* | .711 | .080 | | | |
| 2:36 a | 18–35 | 3.12 | 1.089 | .877 | *.715* | .080 | | | |
| 1:55 a | 23–05 | 2.54 | 1.291 | *.931* | .759 | .040 | | | |
| 1:50 a | 23–25 | 2.51 | 1.298 | .937 | *.762* | .040 | | | |
| 0:40 a | 27–54 | 2.14 | 1.350 | .948 | *.771* | .035 | | | |
| 0:36 a | 28–02 | 2.12 | 1.367 | *.951* | .775 | .035 | 5 | | P=54.6. |
| 1:31 p | 24–49 | 2.38 | 1.343 | *.894* | .723 | .020 | | | |
| 1:37 p | 24–46 | 2.38 | 1.320 | .897 | *.726* | .025 | | | |
| 2:09 p | 21–41 | 2.69 | 1.254 | .882 | *.727* | .030 | | | |
| 2:16 p | 20–51 | 2.80 | 1.268 | *.885* | .729 | .030 | | | |
| Jan. 10 | | | | | | | | | |
| 3:13 a | 14–14 | 4.02 | .863 | *.700* | .582 | .080 | | 401 | |
| 3:09 a | 14–46 | 3.86 | .888 | .705 | *.585* | .075 | | | |
| 2:31 a | 19–38 | 2.96 | 1.096 | .822 | *.691* | .030 | | | |
| 2:27 a | 20–06 | 2.89 | 1.114 | *.835* | .694 | .025 | | | |

TABLE 3.—*Solar radiation measurements, and determinations of atmospheric factor, β, Washington, D. C., January, 1933*—Con.

[Values in italics have been interpolated]

| Date and solar hour angle | Solar altitude, h. | Air mass, m. | $I_m$ | $I_y$ | $I_r$ | β | Blueness of sky | Atmospheric dust particles per cubic centimeter | Notes: Skylight polarization, P., clouds, etc. |
|---|---|---|---|---|---|---|---|---|---|
| 1933 Jan. 10 | | | *gr. cal.* | *gr. cal.* | *gr. cal.* | | | | |
| 0:47 a | 28–12 | 2.11 | 1.228 | *0.901* | 0.726 | 0.070 | | | |
| 0:41 a | 28–24 | 2.10 | 1.254 | .906 | *.729* | .065 | | | |
| Jan. 16 | | | | | | | | | |
| 0:24 a | 29–54 | 2.01 | 1.254 | *.963* | .774 | .080 | | 758 | |
| 0:21 a | 29–58 | 2.00 | 1.260 | .967 | *.777* | .080 | | | |
| 1:11 p | 27–55 | 2.14 | 1.127 | .911 | *.744* | .130 | | | |
| 1:15 p | 27–31 | 2.16 | 1.137 | *.914* | .747 | .130 | | | |
| Jan. 20 | | | | | | | | | |
| 3:19 a | 15–10 | 3.77 | 1.037 | .804 | *.660* | .055 | | 1157 | |
| 3:13 a | 15–42 | 3.64 | 1.042 | *.808* | .663 | .055 | | | |
| 2:53 a | 18–28 | 3.13 | 1.180 | *.873* | .711 | .040 | | | |
| 2:50 a | 18–50 | 3.08 | 1.190 | .876 | *.714* | .040 | | | |
| 2:11 a | 23–32 | 2.50 | 1.264 | .914 | *.760* | .045 | | | |
| 2:07 a | 23–55 | 2.46 | 1.269 | .921 | .763 | .045 | | | |
| 1:07 a | 28–58 | 2.06 | 1.385 | *.967* | .774 | .030 | | | |
| 103 a | 29–14 | 2.05 | 1.403 | .970 | .778 | .025 | | | Cirri. |
| Jan. 23 | | | | | | | | | |
| 0:04 a | 31–40 | 1.90 | 1.062 | .851 | *.688* | .090 | | | |
| 0:08 p | 31–38 | 1.90 | 1.048 | *.856* | .691 | .100 | | | |

TABLE 3.—*Solar radiation measurements, and determinations of atmospheric factor, β, Washington, D. C., January, 1933*—Con.

[Values in italics have been interpolated]

| Date and solar hour angle | Solar altitude, h. | Air mass, m. | $I_m$ | $I_s$ | $I_r$ | β | Blueness of sky | Atmospheric dust particles per cubic centimeter | Notes: Skylight polarization, P., clouds, etc. |
|---|---|---|---|---|---|---|---|---|---|
| 1933 | | | | | | | | | |
| Jan. 24 | | | gr. cal. | gr. cal. | gr. cal. | | | | |
| 2:38 a | 21-08 | 2.76 | 1.107 | .853 | .693 | .070 | | | |
| 2:28 a | 20-22 | 2.61 | 1.139 | .856 | .699 | .070 | | | |
| 2:04 a | 25-04 | 2.36 | 1.145 | .870 | .703 | .080 | | | |
| 0:52 a | 30-38 | 1.96 | 1.241 | .945 | .711 | .070 | 4 | | P=55.8. |
| 0:44 a | 30-59 | 1.94 | 1.274 | .945 | .714 | .065 | | | |
| 0:04 a | 31-54 | 1.89 | 1.276 | .945 | .747 | .075 | | | |
| 0:00 noon | 31-54 | 1.89 | 1.300 | .945 | .748 | .070 | | | |
| 1:08 p | 29-45 | 2.01 | 1.292 | .916 | .746 | .065 | | | |
| 1:12 p | 29-30 | 2.02 | 1.303 | .918 | .747 | .060 | | | |
| 2:08 p | 24-39 | 2.39 | 1.200 | .967 | .705 | .055 | | | |
| 2:12 p | 24-13 | 2.43 | 1.203 | .970 | .708 | .055 | | | |
| Jan. 30 | | | | | | | | | |
| 3:28 a | 15-28 | 3.70 | 1.067 | .964 | .702 | .065 | | 355 | |
| 3:17 a | 16-31 | 3.49 | 1.150 | .967 | .704 | .040 | | | |
| 2:30 a | 23-31 | 2.50 | 1.200 | .948 | .736 | .045 | | | |
| 2:24 a | 24-15 | 2.43 | 1.216 | .951 | .789 | .045 | | | |
| 1:41 a | 28-56 | 2.06 | 1.355 | .999 | .814 | .060 | | | |
| 1:33 a | 29-21 | 2.04 | 1.310 | 1.015 | .817 | .085 | | | |
| Jan. 31 | | | | | | | | | |
| 3:36 a | 14-27 | 3.97 | .909 | .717 | .606 | .070 | | 389 | |
| 3:31 a | 15-14 | 3.77 | .906 | .720 | .609 | .080 | | | |
| 3:08 a | 18-39 | 3.11 | 1.016 | .802 | .655 | .080 | | | |
| 3:02 a | 19-30 | 2.98 | 1.029 | .804 | .658 | .065 | | | |
| 3:42 a | 22-15 | 2.63 | 1.032 | .846 | .698 | .115 | | | |
| 2:34 a | 23-16 | 2.51 | 1.126 | .847 | .697 | .080 | | | |
| 2:03 a | 26-54 | 2.21 | 1.174 | .885 | .711 | .085 | | | |
| 1:58 a | 27-24 | 2.17 | 1.174 | .888 | .712 | .085 | | | |
| 1:22 a | 30-35 | 1.96 | 1.221 | .897 | .723 | .080 | 5 | | P=58.3. |
| 1:18 a | 30-53 | 1.94 | 1.243 | .900 | .726 | .075 | | | |

## POSITIONS AND AREAS OF SUN SPOTS

[Communicated by Capt. J. F. Hellweg, Superintendent United States Nava Observatory. Data furnished by Naval Observatory, in cooperation with Harvard, Perkins, and Mount Wilson Observatories. The differences of longitude are measured from central meridian, positive west. The north latitudes are plus. Areas are corrected for foreshortening and are expressed in millionths of sun's visible hemisphere. The total area, including spots and groups, is given for each day in the last column]

| Date | Eastern standard civil time | Heliographic | | | Area | | Total area for each day |
|---|---|---|---|---|---|---|---|
| | | Diff. long. | Longitude | Latitude | Spot | Group | |
| 1933 | h. m. | ° | ° | ° | | | |
| Jan. 1 (Naval Observatory) | 12 29 | No spots. | | | | | |
| Jan. 2 (Naval Observatory) | 11 40 | No spots. | | | | | |
| Jan. 3 (Naval Observatory) | 13 23 | −70.0 | 328.1 | +11.0 | 185 | | 185 |
| Jan. 4 (Naval Observatory) | 11 3 | −74.0 | 313.3 | +11.0 | | 185 | |
| | | −59.0 | 328.3 | +11.0 | 170 | | 355 |
| Jan. 5 (Naval Observatory) | 14 6 | −59.0 | 313.5 | +10.0 | | 154 | |
| | | −44.0 | 328.5 | +10.0 | 154 | | 308 |
| Jan. 6 (Naval Observatory) | 12 15 | −46.0 | 314.3 | +9.0 | 93 | | |
| | | −32.0 | 328.3 | +10.0 | 154 | | 247 |
| Jan. 7 (Mount Wilson) | 12 50 | −32.0 | 314.9 | +9.0 | 110 | | |
| | | −18.0 | 328.9 | +11.0 | 126 | | 236 |
| Jan. 8 (Naval Observatory) | 13 1 | −18.0 | 315.6 | +10.0 | 123 | | |
| | | −4.0 | 329.6 | +11.0 | 154 | | 277 |
| Jan. 9 (Mount Wilson) | 13 50 | −5.0 | 315.0 | +9.0 | 109 | | |
| | | +9.0 | 329.0 | +11.0 | 166 | | 275 |
| Jan. 10 (Naval Observatory) | 11 55 | +8.0 | 315.8 | +10.0 | | 154 | |
| | | +22.0 | 329.8 | +11.0 | 139 | | 293 |
| Jan. 11 (Perkins Observatory) | 15 40 | +20.0 | 312.6 | +11.0 | 70 | | |
| | | +32.0 | 324.6 | +11.0 | 70 | | 140 |

## POSITIONS AND AREAS OF SUN SPOTS—Continued

[Communicated by Capt. J. F. Hellweg, Superintendent United States Naval Observatory. Data furnished by Naval Observatory, in cooperation with Harvard, Perkins, and Mount Wilson Observatories. The differences of longitude are measured from central meridian, positive west. The north latitudes are plus. Areas are corrected for foreshortening and are expressed in millionths of sun's visible hemisphere. The total area, including spots and groups, is given for each day in the last column]

| Date | Eastern standard civil time | Heliographic | | | Area | | Total area for each day |
|---|---|---|---|---|---|---|---|
| | | Diff. long. | Longitude | Latitude | Spot | Group | |
| 1933 | h. m. | ° | ° | ° | | | |
| Jan. 12 (Naval Observatory) | 13 30 | +4.0 | 284.6 | +8.0 | | 31 | |
| | | +36.0 | 316.6 | +10.0 | 123 | | |
| | | +49.0 | 329.6 | +11.0 | 139 | | 293 |
| Jan. 13 (Perkins Observatory) | 15 0 | +5.0 | 271.7 | +5.0 | | 45 | |
| | | +34.0 | 300.7 | +15.0 | | 50 | |
| | | +46.0 | 312.7 | +11.0 | 70 | | |
| | | +59.0 | 325.7 | +11.0 | 70 | | 235 |
| Jan. 14 (Mount Wilson) | 12 0 | +20.0 | 278.1 | +3.0 | | 53 | |
| | | +51.0 | 306.1 | +15.0 | | 74 | |
| | | +62.0 | 317.1 | +10.0 | 85 | | |
| | | +75.0 | 330.1 | +11.0 | 171 | | 383 |
| Jan. 15 (Naval Observatory) | 13 16 | +33.0 | 274.2 | +3.0 | | 37 | |
| | | +66.0 | 307.2 | +14.0 | | 62 | |
| | | +76.0 | 317.2 | +10.0 | 108 | | 207 |
| Jan. 16 (Naval Observatory) | 10 43 | +46.0 | 275.5 | +2.0 | | 19 | 19 |
| Jan. 18 (Harvard Observatory) | | No spots. | | | | | |
| Jan. 19 (Perkins Observatory) | 13 15 | No spots. | | | | | |
| Jan. 20 (Naval Observatory) | 11 5 | No spots. | | | | | |
| Jan. 22 (Naval Observatory) | 16 25 | No spots. | | | | | |
| Jan. 23 (Naval Observatory) | 10 20 | No spots. | | | | | |
| Jan. 24 (Naval Observatory) | 10 44 | No spots. | | | | | |
| Jan. 28 (Naval Observatory) | 10 47 | −58.0 | 13.4 | +6.0 | | 31 | 31 |
| Jan. 29 (Naval Observatory) | 11 19 | −44.0 | 14.0 | +5.0 | | 154 | 154 |
| Jan. 30 (Naval Observatory) | 10 56 | −79.0 | 326.0 | +12.0 | 123 | | |
| | | −33.0 | 12.0 | +4.0 | | 50 | |
| | | −26.0 | 19.0 | +5.0 | | 77 | 250 |
| Jan. 31 (Naval Observatory) | 11 5 | −88.0 | 303.8 | +16.0 | 247 | | |
| | | −64.0 | 327.8 | +12.0 | | 108 | |
| | | −15.0 | 16.8 | +6.0 | | 216 | 571 |
| Mean daily area for January | | | | | | | 172 |

## PROVISIONAL SUN-SPOT RELATIVE NUMBERS FOR JANUARY, 1933

(Dependent alone on observations at Zurich and its station at Arosa)

[Data furnished through the courtesy of Prof. W. Brunner, University of Zurich, Switzerland]

| January, 1933 | Relative numbers | January, 1933 | Relative numbers | January, 1933 | Relative numbers |
|---|---|---|---|---|---|
| 1 | 0 | 11 | 17 | 21 | 0 |
| 2 | 0 | 12 | *Mc* 26 | 22 | 0 |
| 3 | *d* 7 | 13 | 37 | 23 | 0 |
| 4 | 14 | 14 | 32 | 24 | 0 |
| 5 | 17 | 15 | 27 | 25 | 0 |
| 6 | 17 | 16 | 14 | 26 | 0 |
| 7 | 19 | 17 | 7 | 27 | 0 |
| 8 | | 18 | 0 | 28 | *Ec* 9 |
| 9 | *a* | 19 | | 29 | 10 |
| 10 | *a* 18 | 20 | 0 | 30 | |
| | | | | 31 | *a* 35 |

Mean: 27 days=11.3.

a=Passage of an average-sized group through the central meridian.
b=Passage of a large group or spot through the central meridian.
c=New formation of a center of activity: E, on the eastern part of the sun's disk; W, on the western part; M, in the central zone.
d=Entrance of a large or average-sized center of activity on the east limb.

# AEROLOGICAL OBSERVATIONS

[Aerological Division, W. R. Gregg, in charge]

By L. T. SAMUELS

Free-air temperatures during January averaged decidedly above normal except at San Diego, where small negative departures occurred. (See Table 1.) The largest positive departures occurred in the lower levels at Omaha and Washington. Relative humidities averaged close to normal at most stations, with the greatest deviations occurring at Omaha where the departures were negative.

In harmony with the large positive temperature departures, the monthly free-air resultant wind directions contained either greater southerly or smaller northerly components than normal at the corresponding stations. In most cases the resultant velocities were above normal. At 3,000 meters elevation and above, however, but little deviation from the normal directions occurred.

Airplane observations were made daily throughout the month at the Weather Bureau stations, with the exception of the 21st at Chicago when, dense fog continued all day.

TABLE 1.—*Free-air temperatures and relative humidities during January, 1933*

TEMPERATURE (°C.)

| Altitude (meters) m. s. l. | Atlanta, Ga. (303 meters)[1] | | Boston, Mass. (6 meters)[2] | | Chicago, Ill. (187 meters)[3] | | Cleveland, Ohio (246 meters)[3] | | Dallas, Tex. (146 meters)[4] | | Ellendale, N. Dak. (444 meters) | | Omaha, Nebr. (300 meters)[5] | | Pensacola, Fla. (2 meters)[6] | | San Diego, Calif. (9 meters)[6] | | Washington, D. C. (2 meters)[6] | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Mean | Departure from normal | Mean | Departure from normal | Mean | Departure from normal | Mean | Departure from normal | Mean | Departure from normal | Mean | Departure from normal | Mean | Departure from normal | Mean | Departure from normal | Mean | Departure from normal | Mean | Departure from normal |
| Surface | 7.2 | (7) | 1.6 | | 0 | (7) | 1.3 | (7) | 8.4 | (7) | −8.8 | +2.3 | −1.3 | (7) | 13.3 | +1.7 | 10.5 | −2.0 | 4.0 | +3.3 |
| 500 | 8.3 | (7) | −.8 | | .2 | (7) | 1.3 | (7) | 11.2 | (7) | −8.5 | +2.5 | −.2 | (7) | 13.2 | +1.9 | 11.4 | −.1 | 5.8 | +4.8 |
| 1,000 | 8.3 | +3.3 | −2.6 | | −.1 | +5.3 | 0 | +5.4 | 10.6 | +4.9 | −4.2 | +4.6 | 1.9 | +6.5 | 11.4 | +1.5 | 9.8 | 0 | 5.8 | +5.7 |
| 1,500 | 7.1 | +3.6 | −3.2 | | −.8 | +5.1 | −1.2 | +4.7 | 8.9 | +3.9 | −4.6 | +3.5 | 1.4 | +5.5 | | | | | | |
| 2,000 | 5.3 | +3.6 | −4.4 | | −2.8 | +4.1 | −2.5 | +4.4 | 7.3 | +3.9 | −7.4 | +2.2 | −.3 | +5.1 | 7.8 | +.8 | 5.4 | +.1 | 2.8 | +5.3 |
| 2,500 | 2.8 | +3.0 | −6.2 | | −5.2 | +3.5 | −4.5 | +4.2 | 5.0 | +3.7 | −10.6 | +1.2 | −3.1 | +4.5 | | | | | | |
| 3,000 | .3 | +2.7 | −8.7 | | −8.3 | +2.7 | −7.3 | +3.7 | 2.1 | +3.2 | −13.3 | +1.1 | −6.1 | +4.0 | 3.6 | +.6 | .4 | −.3 | −1.8 | +4.1 |
| 4,000 | −5.1 | +2.5 | −15.0 | | −14.3 | +1.5 | −12.6 | +3.2 | −3.9 | +2.7 | −19.9 | −.1 | −12.4 | +3.0 | −1.6 | +.6 | −4.8 | −.3 | | |
| 5,000 | −12.0 | +1.2 | −20.2 | | −21.1 | +1.5 | −19.1 | +3.5 | −10.5 | +2.2 | | | −19.2 | +2.3 | | | | | | |

RELATIVE HUMIDITY (PER CENT)

| | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Surface | 84 | (7) | 69 | | 82 | (7) | 80 | (7) | 81 | (7) | 82 | +1 | 77 | (7) | 85 | +2 | 70 | +5 | 78 | +7 |
| 500 | 77 | (7) | 67 | | 75 | (7) | 78 | (7) | 66 | (7) | 81 | +2 | 71 | (7) | 80 | +4 | 62 | +1 | 64 | +2 |
| 1,000 | 68 | +11 | 67 | | 67 | +2 | 72 | +7 | 60 | −1 | 68 | +2 | 56 | −10 | 76 | +7 | 59 | +5 | 54 | −3 |
| 1,500 | 63 | +10 | 62 | | 59 | +1 | 61 | +3 | 53 | −1 | 64 | +5 | 47 | −12 | | | | | | |
| 2,000 | 57 | +8 | 59 | | 54 | +1 | 49 | −4 | 45 | −4 | 63 | +5 | 41 | −16 | 70 | +13 | 50 | +8 | 45 | −6 |
| 2,500 | 50 | +5 | 55 | | 50 | −3 | 47 | −6 | 43 | −3 | 65 | +7 | 40 | −16 | | | | | | |
| 3,000 | 45 | +2 | 52 | | 48 | −6 | 47 | −7 | 42 | 0 | 64 | +6 | 39 | −17 | 61 | +13 | 41 | +9 | 41 | −2 |
| 4,000 | 40 | −2 | 52 | | 47 | −8 | 49 | −6 | 39 | +1 | 66 | +12 | 38 | −15 | 54 | +13 | 33 | +9 | | |
| 5,000 | 36 | −15 | 48 | | 43 | −16 | 45 | −14 | 41 | +5 | | | 37 | −17 | | | | | | |
| | | | | | 42 | | | | | | | | | | | | | | | |

Weather Bureau airplane observations made near 5 a. m.; Navy airplane observations near 7 a. m.; Ellendale kite observations near 9 a. m. (seventy-fifth meridian time).

[1] Temperature and humidity departures based on normals of Due West, S. C.
[2] Observations made by Massachusetts Institute of Technology.
[3] Temperature and humidity departures based on normals of Royal Center, Ind.
[4] Temperature departures based on normals determined by interpolating between those of Groesbeck, Tex., and Broken Arrow, Okla. Humidity departures based on normals of Groesbeck, Tex.
[5] Temperature and humidity departures based on normals of Drexel, Nebr.
[6] Naval air stations.
[7] Surface and 500-meter departures omitted because of difference in time between airplane observations and those of kites upon which the normals are based.

TABLE 2.—*Free-air resultant winds (meters per second) based on pilot balloon observations made near 7 a. m. (E. S. T.) during January, 1933*

[Wind from N=360°; E=90°, etc.]

| Altitude (meters) m. s. l. | Albuquerque, N. Mex. (1,528 meters) | | Atlanta, Ga. (309 meters) | | Bismarck, N. Dak. (518 meters) | | Brownsville, Tex. (12 meters) | | Burlington, Vt. (132 meters) | | Cheyenne, Wyo. (1,873 meters) | | Chicago, Ill. (192 meters) | | Cleveland, Ohio (245 meters) | | Dallas, Tex. (154 meters) | | Havre, Mont. (762 meters) | | Jacksonville, Fla. (14 meters) | | Key West, Fla. (11 meters) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Direction | Velocity | Direction | Velocity | Direction | Velocity | Direction | Velocity | Direction | Velocity | Direction | Velocity | Direction | Velocity | Direction | Velocity | Direction | Velocity | Direction | Velocity | Direction | Velocity | Direction | Velocity |
| | ° | | ° | | ° | | ° | | ° | | ° | | ° | | ° | | ° | | ° | | ° | | ° | |
| Surface | 26 | 0.7 | 314 | 1.4 | 300 | 0.8 | 149 | 1.0 | 199 | 1.6 | 274 | 6.1 | 228 | 2.5 | 211 | 3.9 | 178 | 1.9 | 253 | 2.6 | 263 | 0.8 | 45 | 1.8 |
| 500 | | | 278 | 3.4 | | | 156 | 6.3 | 227 | 5.2 | | | 234 | 9.1 | 233 | 7.8 | 219 | 5.4 | | | 251 | 3.5 | 90 | 3.1 |
| 1,000 | | | 256 | 5.9 | 281 | 7.3 | 165 | 7.0 | 246 | 7.2 | | | 247 | 12.0 | 258 | 11.0 | 248 | 7.2 | 252 | 8.5 | 256 | 3.9 | 145 | 1.9 |
| 1,500 | | | 269 | 6.4 | 284 | 9.8 | 179 | 5.7 | 259 | 8.7 | | | 258 | 13.5 | 268 | 10.7 | 257 | 6.8 | 269 | 11.0 | 271 | 4.5 | 237 | 1.4 |
| 2,000 | 278 | 2.6 | 278 | 7.2 | 287 | 11.0 | 218 | 4.7 | 289 | 9.0 | 267 | 9.4 | 268 | 13.1 | 269 | 12.2 | 262 | 9.3 | 276 | 12.1 | 294 | 5.2 | 259 | 2.1 |
| 2,500 | 266 | 5.3 | 281 | 8.2 | 282 | 13.4 | 255 | 2.9 | 295 | 8.9 | 273 | 15.8 | 277 | 13.1 | 269 | 14.0 | 257 | 11.5 | 274 | 12.5 | 294 | 6.4 | 256 | 3.2 |
| 3,000 | 266 | 8.4 | 278 | 9.2 | 276 | 13.6 | 241 | 2.6 | 265 | 7.8 | 280 | 16.4 | | | 271 | 13.0 | 261 | 12.3 | 275 | 12.8 | 288 | 8.9 | 262 | 3.2 |
| 4,000 | 268 | 11.5 | 284 | 10.6 | | | 262 | 8.7 | | | 284 | 13.9 | | | | | 262 | 12.8 | 256 | 8.6 | | | 248 | 2.7 |
| 5,000 | 284 | 8.3 | | | | | | | | | 264 | 7.9 | | | | | | | | | | | 266 | 9.3 |

| Altitude (meters) m. s. l. | Los Angeles, Calif. (217 meters) | | Medford, Oreg. (410 meters) | | Memphis, Tenn. (83 meters) | | New Orleans, La. (25 meters) | | Oakland, Calif. (8 meters) | | Oklahoma City, Okla. (402 meters) | | Omaha, Nebr. (306 meters) | | Phoenix, Ariz. (356 meters) | | Salt Lake City, Utah (1,294 meters) | | Sault Ste. Marie, Mich. (198 meters) | | Seattle, Wash. (14 meters) | | Washington, D. C. (10 meters) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Direction | Velocity | Direction | Velocity | Direction | Velocity | Direction | Velocity | Direction | Velocity | Direction | Velocity | Direction | Velocity | Direction | Velocity | Direction | Velocity | Direction | Velocity | Direction | Velocity | Direction | Velocity |
| | ° | | ° | | ° | | ° | | ° | | ° | | ° | | ° | | ° | | ° | | ° | | ° | |
| Surface | 98 | 1.0 | 169 | 0.5 | 206 | 1.7 | 62 | 1.0 | 90 | 1.5 | 201 | 3.1 | 223 | 0.9 | 91 | 1.5 | 167 | 3.3 | 134 | 0.5 | 155 | 3.0 | 306 | 1.8 |
| 500 | 106 | 1.2 | 176 | 1.3 | 250 | 5.5 | 191 | 2.2 | 31 | 1.9 | 212 | 4.1 | 234 | 4.1 | 102 | 2.0 | | | 171 | 1.5 | 197 | 6.6 | 278 | 6.6 |
| 1,000 | 287 | 0.6 | 231 | 2.7 | 265 | 6.3 | 237 | 3.3 | 334 | 3.6 | 248 | 8.3 | 269 | 8.2 | 108 | 1.8 | | | 220 | 2.5 | 209 | 7.0 | 277 | 8.5 |
| 1,500 | 274 | 1.4 | 260 | 3.8 | 280 | 6.6 | 217 | 3.8 | 331 | 4.7 | 253 | 8.5 | 273 | 10.5 | 194 | 2.2 | 180 | 4.8 | 273 | 4.1 | 238 | 5.9 | 292 | 10.1 |
| 2,000 | 310 | 2.5 | 282 | 5.5 | 274 | 8.4 | 268 | 4.0 | 328 | 6.3 | 251 | 9.9 | 276 | 11.8 | 233 | 4.1 | 199 | 4.2 | 274 | 4.7 | 281 | 5.3 | 294 | 11.0 |
| 2,500 | 306 | 5.0 | 289 | 5.6 | 272 | 10.9 | 267 | 4.3 | 329 | 7.4 | 256 | 11.1 | 274 | 13.5 | 242 | 5.0 | 244 | 4.8 | 265 | 5.5 | | | 283 | 12.7 |
| 3,000 | 303 | 6.4 | 314 | 6.2 | 268 | 13.1 | | | 314 | 8.5 | 270 | 11.4 | 267 | 13.2 | 250 | 6.5 | 262 | 6.7 | 282 | 8.0 | | | 280 | 14.1 |
| 4,000 | 289 | 6.7 | | | | | | | 313 | 7.0 | 294 | 10.1 | | | 274 | 10.1 | 287 | 9.2 | | | | | | |
| 5,000 | | | | | | | | | | | | | | | 267 | 8.3 | | | | | | | | |

# RIVERS AND FLOODS

By MONTROSE W. HAYES

[In charge River and Flood Division]

In January, 1933, floods occurred in the South Atlantic, the Gulf, and the Ohio Valley States, and in Oregon. The most important were in the Coosa, Alabama, and Tombigbee Rivers of Alabama, the White and Wabash of Indiana, the St. Francis and Ouachita of Arkansas, and the Tallahatchie of Mississippi.

The floods in the rivers of Alabama were a continuation of December rises, and the crest stages occurred in December, except in the lower reaches of the streams.

There were two rises in the White and Wabash. The first, from December 24 to January 9, was of moderate severity. The second was of minor consequence and prevailed from January 22 until the early part of February, but falling stages prevailed at the close of January.

In the St. Francis and Ouachita Rivers there also were two distinct rises. Both of those in the St. Francis were rather severe. In the Ouachita the first caused some damage, but the second was very little above bankful, and no damage resulted.

The flood in the Tallahatchie had not subsided at the end of January; it will be discussed in a later issue of the REVIEW.

Rains prevailed over the Willamette Basin in the latter part of December. They became heavy on January 1 and flood stages were rather general in the Willamette and most of its tributaries. The overflow was quite extensive, but it subsided rapidly.

Timely warnings of all the January floods were issued.

The usual tabulation of losses caused by floods is being discontinued as a monthly statement. In an effort to prevent duplication that might occur in some cases, and to obtain data that are more nearly complete in other cases, the tabulation will be published at the end of each year.

*Table of flood stages in January, 1933*

[All dates in January unless otherwise specified]

| River and station | Flood stage | Above flood stages—dates | | Crest | |
|---|---|---|---|---|---|
| | | From— | To— | Stage | Date |
| ST. LAWRENCE DRAINAGE | | | | | |
| | *Feet* | | | *Feet* | |
| Sandusky: Upper Sandusky, Ohio | 13 | 1 | 1 | 14.2 | 1. |
| ATLANTIC SLOPE DRAINAGE | | | | | |
| Roanoke: Williamston, N. C | 10 | Dec. 30 | 19 | 12.2 | 5. |
| Cape Fear: Elizabethtown, N. C | 20 | Dec. 26 | 1 | 26.2 | Dec. 29. |
| Peedee: | | | | | |
| Mars Bluff Bridge, S. C | 17 | Dec. 15 | 8 | 21.2 | 2. |
| | | 12 | 15 | 17.3 | 13, 14. |
| Poston, S. C | 18 | Dec. 19 | 10 | 21.4 | 4. |
| Saluda: Chappells, S. C | 14 | Dec. 27 | 1 | 18.6 | Dec. 29. |
| Santee: | | | | | |
| Rimini, S. C | 12 | Dec. 14 | 20 | 18.1 | 2. |
| | | 26 | (1) | 13.7 | 29. |
| Ferguson, S. C | 12 | Dec. 15 | 24 | 14.1 | 2, 3. |
| | | 26 | (1) | 13.3 | 31. |
| Savannah: Ellenton, S. C | 14 | Dec. 13 | 22 | 23.1 | Dec. 31. |
| | | 26 | (1) | 17.5 | 29. |
| Ocmulgee: Abbeville, Ga | 11 | 3 | 8 | 13.1 | 5. |
| Altamaha: | | | | | |
| Charlotte, Ga | 12 | 2 | 2 | 12.8 | 2. |
| Everett City, Ga | 10 | 13 | 17 | 10.4 | 14, 15. |
| EAST GULF OF MEXICO DRAINAGE | | | | | |
| Apalachicola: Blountstown, Fla | 15 | 28 | Feb. 1 | 16.6 | 30. |
| Oostanaula: | | | | | |
| Resaca, Ga | 22 | Dec. 28 | 2 | 31.2 | Dec. 29. |
| Rome, Ga | 30 | do | 3 | 33.8 | Dec. 30. |

*Table of flood stages in January, 1933*—Continued

[All dates in January unless otherwise specified]

| River and station | Flood stage | Above flood stages—dates | | Crest | |
|---|---|---|---|---|---|
| | | From— | To— | Stage | Date |
| EAST GULF OF MEXICO DRAINAGE—continued | | | | | |
| Coosa: | *Feet* | | | *Feet* | |
| Mayos Bar Lock, Ga | 28 | Dec. 27 | 4 | 37.0 | Dec. 30. |
| Gadsden, Ala | 22 | Dec. 13 | 9 | 30.3 | 2. |
| Lock No. 4, Lincoln, Ala | 17 | do | 10 | 23.2 | Dec. 18. |
| Wetumpka, Ala | 45 | Dec. 28 | 1 | 48.9 | Dec. 30. |
| Alabama: | | | | | |
| Montgomery, Ala | 35 | Dec. 17 | 8 | 49.5 | Dec. 31. |
| Selma, Ala | 35 | do | 12 | 50.8 | 2. |
| Millers Ferry, Ala | 35 | do | 16 | 51.8 | 3, 4. |
| Tombigbee: | | | | | |
| Lock No. 4, Demopolis, Ala | 39 | Dec. 13 | 17 | 62.7 | Dec. 22. |
| Lock No. 3, Ala | 33 | Dec. 12 | 20 | 60.6 | Dec. 26. |
| | | 26 | 31 | 38.0 | 28. |
| Lock No. 2, Ala | 46 | Dec. 14 | 18 | 62.5 | Dec. 26, 27 |
| Lock No. 1, Ala | 31 | do | 22 | 44.4 | Dec. 29. |
| Pearl: Edinburg, Miss | 20 | Dec. 25 | 3 | 23.1 | Do. |
| West Pearl: Pearl River, La | 13 | Dec. 17 | 25 | 16.5 | Dec. 31, 1. |
| MISSISSIPPI SYSTEM | | | | | |
| *Upper Mississippi Basin* | | | | | |
| Illinois: Peru, Ill | 14 | 22 | (1) | 14.5 | 22, 24, 29. |
| *Ohio Basin* | | | | | |
| Scioto: | | | | | |
| Prospect, Ohio | 10 | 1 | 3 | 12.1 | 2. |
| Circleville, Ohio | 10 | 1 | 3 | 14.8 | 2. |
| Chillicothe, Ohio | 16 | 2 | 3 | 17.1 | 3. |
| Licking: Falmouth, Ky | 28 | 22 | 23 | 29.7 | 22. |
| Miami: Middletown, Ohio | 15 | 1 | 1 | 16.0 | 1. |
| Barren: Bowling Green, Ky | 20 | 23 | 26 | 24.7 | 24. |
| Green: | | | | | |
| Munfordville, Ky | 28 | 22 | 26 | 35.7 | 24. |
| Lock No. 6, Brownsville, Ky | 28 | 22 | 27 | 34.7 | 25. |
| Lock No. 4, Woodbury, Ky | 33 | 22 | 30 | 42.5 | 26. |
| Lock No. 2, Rumsey, Ky | 34 | 24 | Feb. 5 | 40.1 | 31. |
| West Fork of White: | | | | | |
| Elliston, Ind | 19 | 1 | 6 | 23.9 | 4. |
| | | 23 | 26 | 20.9 | 25. |
| Edwardsport, Ind | 12 | Dec. 25 | 9 | 18.8 | 5. |
| | | 22 | 31 | 18.1 | 24-26. |
| East Fork of White: | | | | | |
| Seymour, Ind | 10 | 1 | 3 | 13.5 | 1. |
| | | 23 | 24 | 12.0 | 23. |
| Williams, Ind | 10 | 3 | 7 | 15.5 | 5. |
| | | 26 | 30 | 13.7 | 27. |
| Shoals, Ind | 20 | 1 | 8 | 26.1 | 6. |
| | | 23 | 31 | 25.0 | 28. |
| White: Decker, Ind | 18 | Dec. 31 | 12 | 22.6 | 8. |
| | | 24 | (1) | 21.8 | 28, 29. |
| Wabash: | | | | | |
| La Fayette, Ind | 13 | 1 | 3 | 16.4 | 2. |
| Covington, Ind | 16 | 2 | 5 | 19.1 | 3, 4. |
| Terre Haute, Ind | 14 | Dec. 27 | 6 | 15.7 | Dec. 31. |
| Vincennes, Ind | 14 | 3 | 4 | 14.0 | 3, 4. |
| Mount Carmel, Ill | 16 | Dec. 29 | 16 | 21.5 | 8, 9. |
| | | 23 | (1) | 20.9 | 28, 29. |
| Cumberland: | | | | | |
| Celina, Tenn | 28 | Dec. 31 | 3 | 32.3 | 2. |
| | | 23 | 26 | 33.5 | 24. |
| Lock F, Eddyville, Ky | 50 | 3 | 7 | 52.1 | 6. |
| Tennessee: | | | | | |
| Rockwood, Tenn | 20 | 1 | 1 | 20.1 | 1. |
| Chattanooga, Tenn | 30 | Dec. 29 | 3 | 37.6 | Dec. 31. |
| Bridgeport, Ala | 18 | do | 4 | 26.0 | 1. |
| Guntersville, Ala | 25 | do | 6 | 34.4 | 3. |
| Decatur, Ala | 20 | 2 | 6 | 20.6 | 3, 5. |
| Florence, Ala | 18 | Dec. 31 | 7 | 20.6 | 5. |
| Riverton Lock, Ala | 33 | Dec. 30 | 9 | 41.1 | 6. |
| Savannah, Tenn | 32 | Dec. 31 | 10 | 40.5 | 7. |
| Johnsonville, Tenn | 31 | 6 | 9 | 31.4 | 8. |
| Ohio: | | | | | |
| Dam No. 47, Newburgh, Ind | 35 | 3 | 3 | 35.3 | 3. |
| | | 25 | Feb. 1 | 38.6 | 28. |
| Evansville, Ind | 35 | 3 | 4 | 35.8 | 3. |
| | | 25 | Feb. 2 | 39.0 | 28. |
| Dam No. 48 | 35 | 26 | Feb. 1 | 37.7 | 29. |
| Mt. Vernon, Ind | 35 | 26 | Feb. 3 | 37.9 | 29. |
| Dam No. 49 | 35 | 27 | Feb. 4 | 37.8 | 30. |
| Shawneetown, Ill | 35 | 2 | 9 | 36.6 | 5, 6. |
| | | 25 | Feb. 6 | 39.5 | 31. |
| Dam No. 50, Fords Ferry, Ky | 32 | 2 | 11 | 37.5 | 5, 6. |
| | | 25 | Feb. 7 | 39.7 | 31. |
| Dam No. 52, Brookport, Ill | 35 | 2 | 12 | 39.8 | 7. |
| | | 26 | Feb. 4 | 36.9 | 31, Feb. 1. |
| Dam No. 53 | 38 | 2 | 12 | 42.6 | 7, 8. |
| | | 27 | Feb. 5 | 40.3 | Feb. 1. |

*Table of flood stages in January, 1933*—Continued

| River and station | Flood stage | Above flood stages—dates | | Crest | |
|---|---|---|---|---|---|
| | | From— | To— | Stage | Date |
| *White Basin* | *Feet* | | | *Feet* | |
| Black: Black Rock, Ark. | 14 | Dec. 31 | 13 | 21.8 | Dec. 31. |
| | | 22 | 29 | 18.3 | 23. |
| White: Georgetown, Ark. | 21 | 1 | 13 | 23.6 | 4. |
| | | 25 | (1) | 22.1 | 30. |
| *Arkansas Basin* | | | | | |
| Petit Jean: Danville, Ark. | 20 | 23 | 25 | 21.5 | 24. |
| Arkansas: Yancopin, Ark. | 29 | 13 | 19 | 29.7 | 16, 17. |
| *Red Basin* | | | | | |
| Little: Whitecliffs, Ark. | 25 | 2 | 3 | 25.6 | 2. |
| Sulphur: | | | | | |
| Ringo Crossing, Tex. | 20 | Dec. 31 | 1 | 22.5 | 1. |
| | | 8 | 11 | 23.5 | 9. |
| | | 22 | 23 | 21.6 | 22. |
| Naples, Tex. | 22 | 2 | 19 | 25.4 | 14. |
| | | 26 | 29 | 22.5 | 28. |
| *Lower Mississippi Basin* | | | | | |
| St. Francis: | | | | | |
| Chaonia, Mo. | 22 | Dec. 31 | 2 | 27.9 | 1. |
| | | 22 | 25 | 29.9 | 23. |
| Fisk, Mo. | 20 | Dec. 25 | 5 | 24.2 | Dec. 27. |
| | | 22 | 27 | 24.3 | 24. |
| St. Francis, Ark. | 18 | Dec. 30 | 12 | 23.4 | 3. |
| | | 23 | (1) | 22.3 | 28. |
| Tallahatchie: Swan Lake, Miss. | 24 | Dec. 16 | (1) | 31.8 | 5-11. |

*Table of flood stages in January, 1933*—Continued

| River and station | Flood stage | Above flood stages—dates | | Crest | |
|---|---|---|---|---|---|
| | | From— | To— | Stage | Date |
| *Lower Mississippi Basin*—Cont'd. | | | | | |
| Ouachita: | *Feet* | | | *Feet* | |
| Arkadelphia, Ark. | 12 | Dec. 31 | 3 | 19.8 | Dec. 31. |
| Camden, Ark. | 26 | 2 | 9 | 31.9 | 5. |
| | | 26 | 27 | 26.0 | 26, 27. |
| Mississippi: New Madrid, Mo. | 34 | 7 | 10 | 34.3 | 8, 9 |
| *Atchafalaya Basin* | | | | | |
| Atchafalaya: Atchafalaya, La. | 22 | 10 | (1) | 22.7 | 23-25. |
| WEST GULF OF MEXICO DRAINAGE | | | | | |
| Trinity: | | | | | |
| Dallas, Tex. | 28 | 9 | 9 | 29.9 | 9. |
| Trinidad, Tex. | 28 | 13 | 14 | 28.5 | 13. |
| PACIFIC SLOPE DRAINAGE | | | | | |
| *Columbia Basin* | | | | | |
| Coast Fork: Saginaw, Oreg. | 9 | 2 | 3 | 12.6 | 2. |
| Long Tom: Monroe, Oreg. | 10 | 2 | 7 | 15.6 | 3. |
| Santiam: Jefferson, Oreg. | 10 | 2 | 2 | 10.0 | 2. |
| Yamhill: McMinnville, Oreg. | 35 | 4 | 5 | 43.6 | 4. |
| Willamette: | | | | | |
| Eugene, Oreg. | 12 | 2 | 3 | 13.2 | 2. |
| Harrisburg, Oreg. | 10 | 3 | 3 | 13.4 | 3. |
| Albany, Oreg. | 20 | 4 | 4 | 21.0 | 4. |
| Oregon City, Oreg. | 12 | 6 | 6 | 12.1 | 6. |

[1] Continued into February.

# THE WEATHER OF THE ATLANTIC AND PACIFIC OCEANS

[By the Marine Division, W. F. McDonald in charge]

## NORTH ATLANTIC OCEAN

By W. F. McDONALD

*Atmospheric pressure.*—The mean pressure over the North Atlantic Ocean during January, 1933, was generally below normal. The Icelandic LOW was especially persistent and at times very intensely active. As a result the monthly average pressure at Reykjavik was almost four-tenths of an inch below normal. The lowest barometer at that place, 27.38 inches on the 3d, must be recorded amongst the extraordinary low readings of the world, as that figure has been surpassed only a few times.

The average pressure was also more than a tenth of an inch below normal from Bermuda to Nova Scotia and to a lesser degree thence eastward over the Azores to the Iberian Peninsula. (See Table 1.)

TABLE 1.—*Averages, departures, and extremes of atmospheric pressure (sea level) at selected stations for the North Atlantic Ocean and its shores, January, 1933*

| Station | Average pressure | Departure | Highest | Date | Lowest | Date |
|---|---|---|---|---|---|---|
| | *Inches* | *Inch* | *Inches* | | *Inches* | |
| Julianehaab, Greenland | 29.38 | ------- | 30.16 | 28 | 28.47 | 2 |
| Reykjavik, Iceland | 29.09 | −0.37 | 30.13 | 26 | 27.38 | 3 |
| Lerwick, Shetland Islands | 29.86 | +.16 | 30.62 | 24 | 28.77 | 3 |
| Valencia, Ireland | 30.02 | +.12 | 30.59 | 9 | 29.16 | 2 |
| Lisbon, Portugal | 30.11 | −.04 | 30.57 | 7 | 29.28 | 28 |
| Madeira | 30.08 | −.02 | ------- | ------- | ------- | ------- |
| Horta, Azores | 30.13 | −.03 | 30.57 | 5 | 29.53 | 27 |
| Belle Isle, Newfoundland | 29.80 | .00 | 30.54 | 14 | 28.92 | 8 |
| Halifax, Nova Scotia | 29.85 | −.13 | 30.70 | 14 | 28 82 | 29 |
| Nantucket | 29.96 | −.08 | 30.62 | 13 | 29.07 | 28 |
| Hatteras | 30.06 | −.08 | 30.51 | 1 | 29.17 | 27 |
| Bermuda | 30.00 | −.16 | 30.34 | 11 | 29.06 | 28 |
| Turks Island | 30.05 | .00 | 30.14 | 20 | 29.84 | 28 |
| Key West | 30.07 | −.03 | 30.26 | 17 | 29.79 | 27 |
| New Orleans | 30.12 | −.01 | 30.61 | 1 | 29.75 | 26 |
| Cape Gracias, Nicaragua | 29.93 | −.05 | 30.02 | 1 | 29.88 | 23 |

NOTE.—All data based on a. m. observations only with departures compiled from best available normals related to time of observation, except Hatteras, Key West, Nantucket, and New Orleans, which are 24-hour corrected means.

An excess in average pressure for the month was observed over the British Isles and North Sea. The highest readings for the Atlantic area proper, 30.68 inches, were reported from several ships near the Azores on the 12th and 13th. The Atlantic HIGH was generally well developed and prominent during the first half of the month, but waned in intensity after the 15th, and was badly disrupted from the 22d until the end of the month.

*Cyclone and sales.— and* gic storms on the North Atlantic were unusually extensive and violent. The preceding month closed with stormy conditions paevalent over the northeastern part of the ocean and this condition continued to intensify as a deep LOW progressed towards Iceland from mid-ocean near latitude 50°, dnring the first three days of January. (See Charts VIII and IX.)

Winds of hurricane violence were encountered by a number of ships over the eastern part of the northern trans-Atlantic routes on the 1st and 2d. Three British steamships, the *Duchess of Atholl*, the *Cameronia*, and the *Lepanto*, reported corrected barometer readings below 28 inches. The lowest reading on the *Lepanto* was 27.43 inches (corrected), at 6 a. m. of the 2d, when the ship was near latitude 54° N. and longitude 32° W. This record must also be placed in the small group of barometer readings which have fallen below 27.50 inches, most of which at sea have been reported from the same part of the North Atlantic.

Gales occurred on some part of the North Atlantic on all but four scattered days in the month, with most widespread and violent storminess on the 1st and 2d and from the 8th to 13th and 25th to 28th. Hurricane force was reported from 10 vessels, eight of these cases on the 1st and 2d in the area north of the 45th parallel and east of the 40th meridian. The other two cases were observed southeast of Cape Hatteras on the 26th and 27th, in connection with an intense, slow moving disturbance

that developed between the coast and Bermuda and caused strong gales to hurricane winds over all the western Atlantic from the Bahamas to Sable Island, between the 25th and 29th.

Notwithstanding the violence and extent of the storm conditions at the opening and towards the close of the month no major ship casualty was reported to have occurred in these periods. Several lives were lost, however, as individual seamen were swept overboard by waves, and many ships suffered delay and minor damage to gear and superstructures.

The only major casualty to shipping, so far as known, came on January 20th, when the British S. S. *Exeter City* was abandoned in sinking condition about 650 miles east of Cape Race. The American S. S. *American Merchant*, under command of Capt. Giles Stedman, was able to rescue the remaining 22 members of the crew of the sinking ship, but Captain Legg of the *Exeter City*, and three of his crew had previously been swept away by the seas, which smashed bridge and boats, and stove in the hatches.

This storm, while undoubtedly very intense near its center, was comparatively small in extent, and moved rapidly from the Grand Banks northeastward between the 18th and 20th without causing widespread storm winds.

*Fog.*—The main trans-Atlantic routes were remarkably free from fog during January, with not more than two days of fog reported in any 5-degree square, and none in most of the area. For the second successive month, however, fog was more than usually prevalent on the north coast of the Gulf of Mexico where it was reported on 11 days in January and on as many as 5 days in a single locality.

## OCEAN GALES AND STORMS, JANUARY, 1933

| Vessel | Voyage | | Position at time of lowest barometer | | Gale began | Time of lowest barometer | Gale ended | Lowest barometer | Direction of wind when gale began | Direction and force of wind at time of lowest barometer | Direction of wind when gale ended | Direction and highest force of wind | Shifts of wind near time of lowest barometer |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | From— | To— | Latitude | Longitude | | | | | | | | | |
| **NORTH ATLANTIC OCEAN** | | | ° ′ | ° ′ | | | | *Inches* | | | | | |
| Bonneville, Nor. M. S. | Charleston | Bremen | 39 55 N | 63 41 W | Dec. 31 | 2a, Jan 1 | Jan. 1 | 29.64 | SW | SSW, 9 | NNW | N, 10 | SSW-W-N. |
| Bremen, Ger. S. S. | Cherbourg | New York | 46 54 N | 37 04 W | Jan. 1 | Noon, 1 | Jan. 2 | 28.74 | WNW | WNW, 11 | W | WNW, 12 | |
| New York, Ger. S. S. | New York | Cherbourg | 45 38 N | 37 57 W | do | 4p, 1 | Jan. 3 | 28.92 | SW | W, 7 | SW | W, 12 | Steady. |
| Leviathan, Am. S. S. | do | do | 49 11 N | 33 57 W | do | 5p, 1 | Jan. 4 | 28.70 | S | WSW, 11 | WNW | W, 12 | |
| Knoxville City, Am. S. S. | Port Said | Savannah | 35 35 N | 7 10 W | do | 10p, 1 | Jan. 2 | 30.12 | SW | SW, — | NW | SW, 8 | SW-NW. |
| Jean Jadot, Belg. S. S. | Antwerp | New York | 50 05 N | 24 52 W | do | 11p, 1 | Jan. 3 | 28.54 | S | SW, 10 | WNW | WNW, 11 | SW-W-WNW. |
| Lepanto, Br. S. S. | Aberdeen | Halifax | 54 08 N | 31 50 W | Dec. 31 | 6a, 2 | Jan. 2 | 27.43 | NNW | NW, 12 | NW | W, 12 | W-NW. |
| American Importer, Am. S. S. | Cherbourg | New York | 49 46 N | 16 18 W | Jan. 1 | 9a, 2 | Jan. 3 | 28.68 | SW | SW, 7 | W | W, 12 | SW-S-W |
| Daytonian, Br. S. S. | Liverpool | Boston | 55 12 N | 11 54 W | do | do | Jan. 5 | 28.10 | S | W, 7 | WNW | W, 10 | S-W-SW. |
| Duchess of Atholl, Br. S. S. | do | Halifax | 53 38 N | 26 46 W | do | 10a, 2 | Jan. 4 | [1] 27.94 | SSW | WSW, 7 | WSW | WSW, 12 | S-WNW-W. |
| Capulin, Am. S. S. | Dundee | Boston | 58 46 N | 8 30 W | do | 2p, 2 | do | 28.25 | S | S, 7 | W | S, 12 | S-WSW. |
| Cameronia, Br. S. S. | Glasgow | New York | 54 42 N | 20 36 W | do | 4p, 2 | do | 27.93 | SW | SW, 10 | WNW | SW, 10 | Slight. |
| Gonzenheim, Ger. S. S. | Antwerp | Lake Charles | 46 54 N | 9 27 W | Jan. 4 | 7p, 4 | Jan. 5 | 29.82 | SW | SW, 9 | NW | SW, 9 | WSW-W-NW. |
| Steel Navigator, Am. S. S. | Port Said | Boston | 38 48 N | 61 34 W | Jan. 5 | Noon, 5 | do | 29.67 | SW | W, 10 | WNW | WNW, 10 | |
| Capulin, Am. S. S. | Dundee | do | 58 20 N | 18 50 W | do | 4p, 5 | Jan. 7 | 29.10 | WSW | SW, 8 | W | SW, 9 | WSW-SW. |
| American Importer, Am. S. S. | Cherbourg | New York | 47 12 N | 37 19 W | Jan. 4 | 3a, 6 | Jan. 6 | 29.22 | W | SSW, 10 | W | W, 12 | W-SSW-W. |
| Katendrecht, Du. M. S. | Rouen | Philadelphia | 49 09 N | 24 16 W | Jan. 6 | 1a, 7 | Jan. 7 | 29.83 | S | SSW, 9 | WSW | SSW, 10 | SSW-WSW. |
| Excalibur, Am S. S. | Gibraltar | New York | 36 08 N | 45 44 W | Jan. 7 | 7a, 7 | do | 29.88 | SSW | SSW, 8 | NE | NNW, 9 | SSW-NNW. |
| McKeesport, Am. S. S. | Rouen | do | 41 08 N | 62 15 W | do | 10p, 7 | Jan. 8 | 29.54 | SW | SW, 9 | WNW | SW, 9 | SW-W. |
| Capulin, Am. S. S. | Dundee | Boston | 56 30 N | 28 50 W | Jan. 8 | 9p, 8 | Jan. 9 | 29.97 | WSW | WSW, 7 | SW | S, 10 | WSW-SSW. |
| Champlain, Fr. S. S. | Plymouth | New York | 46 10 N | 41 20 W | do | 10p, 8 | do | 29.70 | S | SSW, — | WSW | SSW, 9 | S-WSW. |
| Wildwood, Am. S. S. | Savannah | London | 36 24 N | 72 41 W | Jan. 9 | 8p, 9 | Jan. 10 | 29.66 | WSW | W, 7 | NNW | NW, 9 | SW-W-NW. |
| Excalibur, Am .S. S. | Gibraltar | New York | 37 48 N | 66 45 W | do | 2a, 10 | do | 29.53 | SSE | WNW, — | NW | WNW, 10 | SSW-WNW. |
| Lepanto, Br. S. S. | Aberdeen | Halifax | 44 52 N | 55 56 W | Jan. 10 | 8a, 10 | do | 29.21 | SE | SSE, 9 | W | SSE, 9 | SSE-S-W. |
| Daytonian, Br. S. S. | Liverpool | Boston | 48 02 N | 44 51 W | do | 9p, 10 | Jan. 11 | 29.08 | SSW | SW, — | NW | SW, 9 | SSW-W-NW. |
| Hoxie, Am. S. S. | Leith | do | 54 17 N | 34 26 W | do | 7a, 11 | Jan. 14 | 28.94 | S | WSW, 9 | NW | WSW, 11 | SSE-W. |
| Black Tern, Am. S. S. | Rotterdam | New York | 49 55 N | 30 02 W | Jan. 11 | 1p, 11 | Jan. 12 | 29.77 | SSW | S, 10 | NW | S-W-WNW. | |
| Bohemian Club, Am. S. S. | Brunswick | Port Arthur | 28 13 N | 89 15 W | Jan. 12 | 8a, 12 | Jan. 13 | 29.98 | NNE | NNE, — | NNE | NNE, 9 | NE-ENE. |
| Black Tern, Am. S. S. | Rotterdam | New York | 47 14 N | 40 37 W | do | Noon 13 | Jan. 14 | 29.89 | W | SSW, 10 | NW | SSW, 10 | SSW-W. |
| Maja, Du. M. S. | Curacao | do | 36 01 N | 76 10 W | do | Mdt, 13 | do | 29.84 | N | ENE, 9 | NE | NNE, 9 | ENE-E-ENE. |
| Scanpenn, Am. S. S. | Hoyanger | Wilmington | 60 41 N | 6 15 W | Jan. 13 | Noon 14 | do | 28.96 | SW | SW, 8 | WSW | SSW, 9 | SSW-W-WSW. |
| Exeter, Am. S. S. | Gibraltar | Boston | 39 07 N | 15 40 W | Jan. 16 | 4a, 17 | Jan. 17 | 29.53 | SSW | WSW, 8 | N | W, 8 | SSW-W-NW. |
| Hoxie, Am. S. S. | Leith | do | 44 47 N | 60 41 W | Jan. 18 | Noon 18 | Jan. 18 | 29.44 | N | N, 8 | N | N, 9 | Steady. |
| Stuttgart, Ger. S. S. | Galway | New York | 47 12 N | 46 06 W | Jan. 19 | 2p, 19 | Jan. 19 | 28.65 | NE | N, 11 | NW | NNW, 11 | N-NNW-NW. |
| Scanpenn, Am. S. S. | Hoyanger | Wilmington | 53 35 N | 38 05 W | do | 2a, 20 | Jan. 20 | 28.54 | SE | NW, 6 | NW | NNW, 9 | SE-SW-NW. |
| Exeter, Am. S. S. | Gibraltar | Boston | 42 45 N | 43 10 W | Jan. 21 | 5p, 21 | Jan. 22 | 29.20 | S | W, 10 | NW | W, 10 | S-WNW-W. |
| John D. Archbold, Am. S. S. | Corpus Christi. | New York | 36 30 N | 74 04 W | Jan. 25 | Noon 25 | Jan. 26 | 29.11 | SE | SSE, 9 | N | N, 9 | SW-N. |
| Waukegan, Am. S. S. | Havre | do | 45 15 N | 41 07 W | do | 10p, 25 | do | 29.16 | S | N, 7 | NW | N, 10 | S-N. |
| Kinai Maru, Jap. S. S. | Baltimore | do | 37 00 N | 75 44 W | Jan. 26 | 4a, 26 | do | 28.97 | NW | NW, 8 | NNE | N, 10 | |
| Patrick Henry, Am. S. S. | Cristobal | Baltimore | 29 40 N | 75 00 W | Jan. 25 | do | do | 29.68 | SW | W, 8 | NW | NW, 9 | W-WNW. |
| China Arrow, Am. S. S. | Boston | Beaumont | 34 32 N | 72 56 W | do | do | Jan. 28 | 29.08 | SE | W, 8 | NW | WNW, 12 | |
| Shickshinny, Am. S. S. | Jacksonville | Liverpool | 46 45 N | 38 40 W | do | do | Jan. 27 | 29.00 | S | SSE, 9 | SE | SSE, 9 | SSE-SE. |
| Statendam, Du. S. S. | New York | Kingston | 39 27 N | 73 53 W | do | 6a, 26 | do | 29.27 | NNE | NNE, 9 | NNE | NNE, 11 | Slight. |
| Cold Harbor, Am. S. S. | Dundee | Boston | 49 30 N | 47 00 W | Jan. 26 | 9a, 26 | Jan. 27 | 29.26 | NNE | NNE, 8 | NNW | N, 9 | N-NNW. |
| City of Elwood, Am. M. S. | New York | Cristobal | 34 55 N | 74 00 W | do | 2p, 27 | Jan. 28 | 29.09 | N | W, 11 | NW | W, 11 | ESE-S-WNW. |
| Borenquin, Am. S. S. | do | San Juan | 33 15 N | 71 05 W | Jan. 27 | 8p, 27 | Jan. 29 | 28.98 | S | SW, 10 | NW | W, 12 | S-SW-W. |
| Coamo, Am. S. S. | San Juan | New York | 21 00 N | 67 00 W | do | 11p, 27 | Jan. 30 | 29.62 | W | W, 7 | NNW | NW, 9 | W-WNW. |
| President Roosevelt, Am. S. S. | Cobh | do | 42 00 N | 61 00 W | do | Mdt., 27 | Jan. 29 | 29.64 | ESE | ESE, 8 | N | E, 10 | |
| Nebraskan, Am. S. S. | New York | Cristobal | 29 07 N | 71 19 W | do | 4a, 28 | Jan. 28 | 29.44 | SSW | W, 9 | W | W, 9 | WSW-W-WNW. |
| Berlin, Ger. S. S. | Southampton | New York | 40 58 N | 66 56 W | do | Noon 28 | Jan. 29 | 28.65 | ESE | NNE, 8 | NW | E, 11 | NE-N. |
| Boschdijk, Du. S. S. | Rotterdam | Boston | 43 16 N | 62 32 W | do | 4p, 28 | do | 28.59 | E | NE, 9 | NNE | NE, 9 | Slight. |

[1] Lowest pressure beyond range of instrument; needle stuck 4 hours at 27.94 inches.

OCEAN GALES AND STORMS, JANUARY, 1933—Continued

| Vessel | Voyage | | Position at time of lowest barometer | | Gale began | Time of lowest barometer | Gale ended | Lowest barometer | Direction of wind when gale began | Direction and force of wind at time of lowest barometer | Direction of wind when gale ended | Direction and highest force of wind | Shifts of wind near time of lowest barometer |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | From— | To— | Latitude | Longitude | | | | | | | | | |
| **NORTH PACIFIC OCEAN** | | | ° ′ | ° ′ | | | | *Inches* | | | | | |
| Tai Yang, Nor. M. S. | Yokohama | San Francisco | 36 45 N | 153 20 W | Dec. 31 | Noon, 31 | Jan. 1 | 29.30 | NE | NNE, 11 | NW | NNE, 11 | NE-N. |
| Delftdijk, Du. M. S. | Balboa | Los Angeles | 14 41 N | 95 16 W | do | —, 1 | do | | WNW | N, 9 | NE | N, 9 | |
| Fernmoor, Nor. M. S. | Vancouver | Shanghai | 51 46 N | 138 04 W | do | 8 a., 3 | Jan. 5 | 29.28 | SW | SSW, 8 | W | SW, 10 | SSW-SW. |
| Kiyo Maru, Jap. S. S. | Yokohama | San Pedro | 39 06 N | 156 40 E | Jan. 1 | 4 a., 4 | do | 29.54 | ESE | W, 7 | NNE | N, 9 | N-NNE. |
| Golden Peak, Am. S. S. | Otaru | San Francisco | 41 33 N | 143 35 E | Jan. 2 | 4 p., 2 | Jan. 4 | 29.91 | N | N, 8 | NNE | N, 9 | N-NNE. |
| Salawati, Du. M. S. | Manila | do | 42 45 N | 154 06 E | do | Noon, 3 | do | 29.54 | SE | NE, 8 | N | NE, 9 | SE-NE. |
| Emp. of Russia, Br. S. S. | Vancouver | Yokohama | 51 41 N | 169 38 W | do | 4 p., 5 | Jan. 6 | 28.80 | SW | NE, 9 | NE | NE, 10 | E-NE-NNE. |
| Varanger, Du. M. S. | Yokohama | San Francisco | 35 59 N | 159 49 E | Jan. 4 | 6 a., 4 | Jan. 4 | 29.72 | WNW | WNW, 8 | NW | NW, 9 | WNW-NW. |
| Tai Yang, Nor. M. S. | do | do | 44 10 N | 168 11 W | Jan. 5 | 6 a., 6 | Jan. 6 | 29.18 | W | WSW, 9 | SW | WSW, 10 | Steady. |
| Tatsuno Maru, Jap. S. S. | do | do | 39 25 N | 162 40 E | Jan. 7 | 2 a., 8 | Jan. 8 | 29.17 | ESE | ENE, 10 | N | ENE, 10 | E-ENE-NE. |
| Fernhill, Nor. M. S. | Manila | San Pedro | 38 08 N | 162 15 W | Jan. 8 | 4 a., 9 | Jan. 9 | 29.61 | SSE | SSE, 9 | SSW | SSE, 10 | SSE-S-SW. |
| Varanger, Du. M. S. | Yokohama | San Francisco | 36 45 N | 176 50 W | do | 6 p., 8 | do | 29.06 | SW | SW | W | WSW, 10 | SW-WSW-W. |
| Kiyo Maru, Jap. S. S. | do | San Pedro | 40 10 N | 175 21 E | do | 6 p., 8 | Jan. 10 | 29.00 | ESE | NE, 10 | NNW | NE, 10 | E-NE-NNE. |
| Pres. Taft, Am. S. S. | Victoria | Yokohama | 50 31 N | 132 46 W | do | 8 p., 8 | Jan. 11 | 29.21 | SE | SSW, 9 | W | SW, 10 | SW-SSW-W. |
| Fernmoor, Nor. M. S. | Vancouver | Shanghai | 52 00 N | 171 35 W | Jan. 9 | 1 p., 9 | Jan. 10 | 29.51 | NE | NNE- | NNW | NNE, 10 | Steady. |
| Salawati, Du. M. S. | Manila | San Francisco | 41 55 N | 179 50 W | Jan. 8 | 2 p., 8 | Jan. 12 | 29.00 | E | NE, 10 | W | NE, 10 | NE-N. |
| Kedoe, Du. M. S. | Ternate | Los Angeles | *28 00 N | *170 00 E | Jan. 10 | 2 a., 12 | Jan. 13 | 29.66 | NW | NW, 12 | NE | NW, 12 | |
| Nairnbank, Br. M. S. | San Pedro | Yokohama | 29 07 N | 178 09 E | Jan. 12 | 6 p., 12 | do | 29.90 | N | NE, 8 | NE | NNE, 9 | NE-NNE. |
| Pres. Taft, Am. S. S. | Victoria | do | 51 00 N | 177 00 W | do | 2 p., 14 | Jan. 14 | 29.62 | WSW | S, 9 | WSW | S, 10 | SW-S-SSE. |
| Golden Tide, Am. S. S. | Hong Kong | San Francisco | 46 58 N | 175 00 E | Jan. 13 | 7 a., 14 | do | 29.26 | E | SW, 8 | SW | SW, 9 | Steady. |
| Maui, Am. S. S. | Honolulu | do | 35 10 N | 131 00 W | Jan. 15 | 4 a., 16 | Jan. 16 | 29.94 | NNW | N, — | NNW | N, 8 | NNW-N. |
| Kuraha Maru, Jap. M. S. | Los Angeles | Yokohama | 46 50 N | 175 08 W | Jan. 16 | | do | | | | | W, 11 | |
| Fernbank, Nor. M. S. | Cebu | San Pedro | 35 12 N | 177 41 E | do | 2 p., 16 | Jan. 17 | 29.65 | S | S, 8 | NNW | SSE, 9 | SSE-NNW. |
| Ogura Maru, Jap. M. S. | Yokohama | do | 35 30 N | 145 15 E | Jan. 17 | 4 a., 18 | Jan. 18 | 29.53 | S | SW, 10 | NW | SW, 10 | S-SW-W. |
| Fernmoor, Nor. M. S. | Vancouver | Shanghai | 44 38 N | 148 55 E | do | 3 p., 18 | Jan. 19 | 28.80 | SSE | Var. — | WNW | E, 11 | E-SW. |
| Mericos H. Whittier, Am. S. S. | Honolulu | San Francisco | 34 50 N | 131 35 W | Jan. 18 | 6 a., 19 | Jan. 20 | 29.74 | NW | NW, 9 | N | NW, 9 | NW-N. |
| Pres. Madison, Am. S. S. | Yokohama | Victoria | 47 22 N | 170 21 E | Jan. 19 | 1 p., 19 | do | 29.80 | SSE | S, 8 | SW | S, 9 | SSE-S. |
| Stanley Dollar, Am. S. S. | Philippines | Los Angeles | 34 20 N | 154 39 E | Jan. 20 | 6 a., 20 | do | 29.98 | N | N, 9 | NNE | N, 9 | SW-N-NNE. |
| Everett, Am. S. S. | Tacoma | Long. 150° W. | *51 48 N | *146 42 W | Jan. 22 | 4 a., 23 | Jan. 24 | 29.06 | WSW | WNW, 7 | W | WNW, 11 | |
| Do. | Long. 150° W | Tacoma | *50 38 N | *148 00 W | Jan. 25 | 4 p., 25 | Jan. 28 | 29.11 | WSW | W, 11 | NW | W, 11 | |
| Admiral Peoples, Am. S. S. | Portland | San Pedro | 45 38 N | 124 16 W | Jan. 22 | 2 p., 22 | Jan. 26 | 29.41 | SSW | SSE, 7 | SW | SSE, 9 | Steady. |
| Wisconsin, Am. S. S. | Japan | San Francisco | 47 00 N | 153 35 W | Jan. 25 | 8 a., 25 | do | 29.86 | W | W, 7 | NW | NW, 10 | W-NW. |
| San Pedro Maru, Jap. M. S. | Yokohama | do | 36 48 N | 154 58 E | Jan. 24 | 6 a., 28 | Jan. 28 | 29.17 | NE | W, 4 | NNE | NNW, 11 | WSW-W. |
| Tacoma, Am. S. S. | Taku Bar | Seattle | 50 00 N | 163 30 W | Jan. 30 | 3 a., 31 | Jan. 31 | 29.00 | E | E, 7 | SE | —, 10 | Calm-E. |
| **SOUTH PACIFIC OCEAN** | | | | | | | | | | | | | |
| Maunganui, Br. S. S. | Rarotonga | Wellington | 22 17 S | 160 52W | Jan. 3 | 12.30 a, 4 | Jan. 4 | 28.62 | N | NW, 11 | S | SSW, 12 | N-NW-SW. |
| Niagara, Br. S. S. | Sydney | Honolulu | 27 30 S | 176 34 E | Jan. 11 | Noon, 11 | Jan. 12 | 28.86 | ESE | NW, 9 | W | NW, 12 | N-NW-W. |

* Position approximate.

## NORTH PACIFIC OCEAN, JANUARY, 1933

By WILLIS E. HURD

*Atmospheric pressure.*—The average center of the Aleutian cyclone shifted somewhat farther eastward than usual during January, 1933. It lay over the Gulf of Alaska, with pressure lower at Juneau, 29.57 inches, than at Kodiak, 29.60 inches, which is very unusual, as the normal pressure at Juneau is .30 inch higher than that at Kodiak. Over the Aleutian Islands pressures were higher than normal, but along most of the American coast east of longitude 150° W., they were below the average for the month.

The eastern Pacific anticyclone remained for most of the month between California and the Hawaiian Islands. High pressure lay off the central Asiatic coast, with average barometric readings about a tenth of an inch above normal over the North China Sea and as far eastward as the Ogasawara Islands.

*Cyclones and gales.*—Gales of force 8 or higher were reported as encountered in some part of the North Pacific Ocean on every day of the month except the 29th, and on 7 or 8 days forces of 11 or 12 were experienced in localities. The greater part of these gales occurred north of the thirtieth parallel. Such continental cyclones as entered the sea area from Asia were apparently weak depressions at the outset, and acquired energy only as they crossed the warm current of the Kuroshiwo. Hence the gales were mainly associated with cyclones of oceanic origin or development. An example of this is the cyclone of January 16–22 which showed little development until the 18th, east of Yezo and the Kuril Islands, when it suddenly attained great depth and swept the whole western end of the northern steamship routes with fierce gales, diminishing on the 19th, as the storm moved across Bering Sea on its way to the Arctic Ocean.

The middle-latitude storm of the 5th to 11th originated at sea southeast of Japan. During the first six days it

TABLE 1.—*Averages, departures, and extremes of atmospheric pressure at sea level, North Pacific Ocean, January, 1933, at selected stations*

| Stations | Average pressure | Departure from normal | Highest | Date | Lowest | Date |
|---|---|---|---|---|---|---|
| | *Inches* | *Inch* | *Inches* | | *Inches* | |
| Point Barrow | 29.93 | −0.15 | 30.38 | 1 | 29.40 | 21 |
| Dutch Harbor | 29.71 | +.13 | 30.28 | 21 | 28.96 | 6 |
| St. Paul | 29.72 | +.09 | 30.18 | 17 | 28.66 | 24 |
| Kokiak | 29.60 | +.01 | 30.50 | 14 | 29.02 | 25 |
| Juneau | 29.57 | −.32 | 30.61 | 15 | 28.93 | 23 |
| Tatoosh Island | 29.80 | −.18 | 30.63 | 11 | 29.09 | 24 |
| San Francisco | 30.05 | −.06 | 30.39 | 12 | 29.54 | 19 |
| Mazatlan | 29.94 | −.08 | 30.00 | 2, 11 | 29.86 | 29 |
| Honolulu | 30.03 | +.03 | 30.20 | 26 | 29.82 | 31 |
| Midway Island | 29.98 | −.05 | 30.24 | 15 | 29.72 | 11 |
| Guam | 29.90 | .00 | 29.98 | 6, 11, 16 | 29.80 | 25 |
| Manila | 29.92 | −.06 | 30.02 | 2, 3 | 29.82 | 19, 20, 21, 22 |
| Naha | 30.19 | +.11 | 30.38 | 13, 14 | 29.96 | 20 |
| Chichishima | 30.09 | +.08 | 30.30 | 9 | 29.88 | 23 |
| Nemuro | 30.02 | | 30.40 | 5 | 29.34 | 17 |

NOTE.—Data based on 1 daily observation only, except those for Juneau, Tatoosh Island, San Francisco, and Honolulu, which are based on 2 observations. Departures are computed from best available normals related to time of observation.

moved across the ocean on a general northeasterly course to the Gulf of Alaska. On the 7th it caused whole gales locally near 40° N., 163° E., and on the 8th and 9th was the source of strong to whole gales over a wide extent in midocean. On the 10th the gale area was over the northeastern waters.

About the 10th the lower extension of a central Aleutian cyclone became detached from the principal storm center. It developed energy on the two following days in low latitudes, resulting in strong northeast gales near Midway Island on the 12th, and northwest winds of hurricane strength, encountered by the Dutch motorship *Kedoe*, to the west of Midway on the 11th and 12th. Thereafter it quickly dissipated.

The stormiest period of the month was the 23d to 26th, when the winds were strongest, within the approximate 10-degree square, 45°–55° N., 140°–150° W., where gales of force 10 to 11 were encountered during the 4 days. The storm abated on the 27th.

On the northern portion of the American coast the principal high winds of the month were a whole gale on the 1st near Vancouver Island, and fresh to strong gales on the 18th and the 22d to 26th off the Washington and Oregon coasts.

The accompanying storm table lists all the important gales of the month that space accommodates, but omits some of the numerous gales of force 8 which have been reported.

*Monsoons and northers.*—Owing to the highly developed state of the Asiatic anticyclones and their projection oceanward, the northeast monsoon was an important meteorological condition during more than half of January over the Japan, Yellow, and North China Seas.

In the Gulf of Tehuantepec less than the normal number of January days with northers occurred. Some Tehuantepecer weather was reported, but the only gales of record in the gulf were one of force 9 on the 1st, and another of force 7 on the 5th.

*Fog.*—Fog increased somewhat in occurrence, both on the United States coast and in midocean, over that of December, 1932. It occurred on 6 days off the California coast; in midocean mostly from the 24th to 29th; and on a few scattered dates in other parts of the sea.

### TROPICAL CYCLONE IN THE SOUTH PACIFIC OCEAN, JANUARY 3–4, 1933

A special report from the R. M. S. *Maunganui*, Cook Islands to Wellington, New Zealand, states that the ship was caught in a cyclone of hurricane intensity in latitude 22° 17′ S., longitude 160° 52′ W., or approximately 80 miles southwest of Rarotonga Island, on the night of January 3–4, 1933.

The vessel left Rarotonga at 5:20 p. m. of the 3d, with heavy rain, backing wind, and falling pressure. At 11 p. m. the wind was north-northeast, force 8, with seas making rapidly. At 11:55 p. m. the wind was from the northwest, force 12, and the ship hove to. At 12:30 a. m. of the 4th the corrected barometer read 969 mb. (28.62 inches). Shortly thereafter the wind moderated to west-southwest, 7, with rising barometer and clear sky overhead. It was followed by renewed hurricane velocities until 2 a. m., after which wind and sea began slowly to abate. Several hands on board received injuries during the storm, and much minor damage was sustained by the ship.—W. E. Hurd.

## CLIMATOLOGICAL TABLES

### DESCRIPTION OF TABLES AND CHARTS

Table 1 gives the data ordinarily needed for climatological studies for about 188 Weather Bureau stations making simultaneous observations at 8 a. m. and 8 p. m. daily, seventy-fifth meridian time, and for about 25 others making only one observation. The altitudes of the instruments above ground are also given.

Beginning with January 1, 1932, all wind movements and velocities published herein are corrected to true values by applying to the anemometer readings corrections determined by actual tests in wind tunnels and elsewhere.

Table 2 gives, for about 36 stations of the Canadian Meteorological Service, the means of pressure and temperature, total precipitation, depth of snowfall, and the respective departures from normal values except in the case of snowfall. The sea-level pressures have been computed according to the method described by Prof. F. H. Bigelow in the REVIEW of January, 1902, **30**: 13–16.

CHART I.—*Temperature departures.*—This chart presents the departures of the monthly mean surface temperatures from the monthly normals. The shaded portions of the chart indicate areas of positive departures and unshaded portions indicate areas of negative departures. Generalized lines connect places having approximately equal departures of like sign. This chart of monthly surface temperature departures in the United States was first published in the MONTHLY WEATHER REVIEW for July, 1909, but smaller charts appear in W. B. Bulletin U for 1873 to June, 1909, inclusive.

CHART II.—*Tracks of centers* of ANTICYCLONES; and

CHART III.—*Tracks of centers* of CYCLONES. The Roman numerals show the chronological order of the centers. The figures within the circles show the days of the month, the location indicated being that at 8 a. m., seventy-fifth meridian time. Within each circle is also an entry of the last three figures of (Chart II) the highest barometric reading, or (Chart III) the lowest reading reported at or near the center at that time, in both cases as reduced to sea level and standard gravity. The intermediate 8 p. m. locations are indicated by dots. The inset map of Chart II shows the departure of monthly mean pressure from normal and the inset of Chart III shows the change in mean pressure from the preceding month.

The use of a new base map for Charts II and III began with the January, 1930, issue.

CHART IV.—*Percentage of clear sky between sunrise and sunset.*—The average cloudiness at each regular Weather Bureau station is determined by numerous personal observations between sunrise and sunset. The difference between the observed cloudiness and 100 is assumed to represent the percentage of clear sky, and the values thus obtained are the basis of this chart. The chart does not relate to the night hours.

CHART V.—*Total precipitation.*—The scales of shading with appropriate lines show the distribution of the monthly precipitation according to reports from both regular and cooperative observers. The inset on this chart shows the departure of the monthly totals from the corresponding normals, as indicated by the reports from the regular stations.

CHART VI.—*Isobars at sea level, average surface temperatures, and prevailing wind directions.*—The pressures have been reduced to sea level and standard gravity by the method described by Prof. Frank H. Bigelow in the

REVIEW for January, 1902, **30**: 13–16. The pressures have also been reduced to the mean of the 24 hours by the application of a suitable correction to the mean of 8 a. m. and 8 p. m. readings at stations taking two observations daily, and to the 8 a. m. or the 8 p. m. observation, respectively, at stations taking but a single observation.

The diurnal corrections so applied, except for stations established since 1901, will be found in the Annual Report of the Chief of the Weather Bureau, 1900–1901, volume 2, Table 27, pages 140–164.

The sea-level temperatures are now omitted and average surface temperatures substituted. The isotherms can not be drawn in such detail as might be desired, for data from only the regular Weather Bureau stations are used.

The prevailing wind directions are determined from hourly observations at almost all the stations. A few stations determine their prevailing directions from the daily or twice-daily observations only.

CHART VII.—*Total snowfall.*—This is based on the reports from regular and cooperative observers and shows the depth in inches of the snowfall during the month. In general, the depth is shown by lines connecting places of equal snowfall, but in special cases figures also are given. This chart is published only when the snowfall is sufficiently extensive to justify its preparation. The inset of this chart, when included, shows the depth of snow on the ground at or near the end of the month.

CHARTS VIII, IX, etc.—*North Atlantic Weather maps of particular days.*

## CONDENSED CLIMATOLOGICAL SUMMARY

In the following table are given for the various sections of the climatological service of the Weather Bureau the monthly average temperature and total rainfall; the stations reporting the highest and lowest temperatures, with dates of occurrence; the stations reporting the greatest and least total precipitation; and other data as indicated by the several headings.

The mean temperature for each section, the highest and lowest temperatures, the average precipitation, and the greatest and least monthly amounts are found by using all trustworthy records available.

The mean departures from normal temperatures and precipitation are based only on records from stations that have 10 or more years of observations. Of course, the number of such records is smaller than the total number of stations.

*Condensed climatological summary of temperature and precipitation by sections, January, 1933*

(Compiled by Annie E. Small)

| Section | Temperature | | | | | | | | Precipitation | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Monthly extremes | | | | | | | | Greatest monthly | | Least monthly | |
| | Section average | Departure from the normal | Station | Highest | Date | Station | Lowest | Date | Section average | Departure from the normal | Station | Amount | Station | Amount |
| | °F. | °F. | | °F. | | | °F. | | In. | In. | | In. | | In. |
| Alabama | 52.6 | +6.3 | Evergreen | 81 | 20 | Florence | 18 | 1 | 3.17 | −1.78 | Clayton | 6.14 | Marion | 1.67 |
| Arizona | 39.0 | −3.8 | Granite Reef Dam | 83 | 8 | Alpine | −17 | 24 | 1.98 | +.82 | Oracle | 7.40 | Tuba City | T |
| Arkansas | 48.8 | +7.5 | Warren | 81 | 19 | Marshall | 11 | 1 | 3.66 | −.62 | Blytheville | 7.33 | Mountain Home | 1.65 |
| California | 39.8 | −4.4 | San Bernardino (near). | 88 | 9 | Bridgeport | −22 | 30 | 6.42 | +1.85 | Dinkey Meadow | 23.01 | Greenland Ranch | .10 |
| Colorado | 25.1 | +1.3 | Two Buttes | 75 | 24 | Alamosa | −30 | 1 | .53 | −.24 | Cumbres | 4.63 | 20 stations | .00 |
| Florida | 62.7 | −3.6 | 2 stations | 88 | [1]8 | 2 stations | 25 | 1 | 2.31 | −.48 | Madison | 6.79 | Everglades | .07 |
| Georgia | 53.6 | +6.5 | do | 83 | [1]20 | Clayton | 14 | 2 | 3.59 | −.61 | Meldrim | 6.57 | Augusta | 1.86 |
| Idaho | 24.0 | +.2 | Orofino | 58 | 2 | Deadwood | −25 | 16 | 2.63 | +.54 | Roland | 12.31 | Grand View | .12 |
| Illinois | 38.6 | +12.2 | Duquoin | 70 | 22 | La Harpe | 4 | 14 | 2.64 | +.33 | Mt. Carmel | 6.27 | 2 stations | .52 |
| Indiana | 38.6 | +10.2 | Shoals | 72 | 22 | Laporte | 5 | 1 | 3.17 | +.04 | Salem | 7.16 | Albion | .84 |
| Iowa | 32.5 | +14.0 | Thurman | 62 | 8 | Northwood | −10 | 14 | .95 | −.12 | Clinton | 2.43 | Inwood (near) | .18 |
| Kansas | 39.3 | +9.8 | Garden City | 72 | 21 | Tribune | 3 | 27 | .25 | −.36 | Pittsburg | 1.20 | 9 stations | .00 |
| Kentucky | 43.9 | +8.1 | Ashland | 74 | 22 | St. John | 10 | 14 | 5.18 | +.78 | Mt. Sterling | 7.50 | Cold Spring | 3.49 |
| Louisiana | 57.2 | +5.7 | 2 stations | 83 | [1]1 | Robeline | 20 | 1 | 3.41 | −1.41 | Port Eads | 7.42 | Bogalusa | .84 |
| Maryland-Delaware | 41.0 | +8.1 | do | 70 | [1]19 | Oakland, Md | 4 | 1 | 3.18 | −.05 | Millsboro, Del | 5.09 | Keedysville, Md | 1.96 |
| Michigan | 29.5 | +9.5 | Monroe | 65 | 22 | Bessemer | −26 | 13 | 1.29 | −.59 | Cassopolis | 3.62 | Bay City | .44 |
| Minnesota | 17.5 | +9.1 | New Ulm | 59 | 7 | 2 stations | −39 | 12 | 1.03 | +.29 | Fosston | 7.46 | Pipestone | .02 |
| Mississippi | 53.5 | +6.5 | 2 stations | 80 | [1]19 | do | 18 | [1]1 | 3.10 | −1.92 | Fruitland Park | 5.94 | Columbus | 1.42 |
| Missouri | 41.4 | +10.9 | Marble Hill | 72 | 18 | do | 8 | [1]12 | 2.43 | +.39 | Marble Hill | 7.87 | Tarkio | .32 |
| Montana | 22.8 | +3.2 | Great Falls | 63 | 9 | Wisdom | −35 | 17 | .90 | +.02 | Heron | 6.25 | Lustre (near) | .02 |
| Nebraska | 32.9 | +11.4 | McCook | 73 | 3 | Nenzel (near) | −9 | 17 | .20 | −.35 | Seward | 1.18 | 11 stations | .00 |
| Nevada | 27.7 | −1.6 | Clay City | 75 | 15 | 3 stations | −18 | [1]15 | 1.76 | +.57 | Kimberly | 5.44 | Thorne | .30 |
| New England | 30.9 | +8.2 | Pittsfield, Mass | 65 | [1]5 | Van Buren, Me | −21 | 14 | 2.38 | −1.01 | Portland, Me | 5.40 | Burlington, Vt | .75 |
| New Jersey | 38.5 | +8.8 | Elizabeth | 67 | 23 | Culvers Lake | 2 | 1 | 2.39 | −1.27 | Port Norris | 4.45 | Elizabeth | 1.38 |
| New Mexico | 32.0 | −1.7 | 4 stations | 71 | [1]5 | Dulce | −24 | 2 | .46 | −.10 | Cloudcroft | 3.04 | 7 stations | .00 |
| New York | 32.8 | +9.6 | 2 stations | 67 | [1]20 | Lake Placid | −19 | 1 | 1.59 | −1.32 | Lyons Falls | 3.21 | Ithaca | .44 |
| North Carolina | 48.1 | +6.6 | New Bern | 80 | 21 | Mt. Mitchell | 6 | 9 | 2.88 | −.79 | Mt. Mitchell | 7.65 | Charlotte | 1.37 |
| North Dakota | 11.8 | +5.6 | New England | 53 | 24 | Mott | −30 | 16 | .80 | +.33 | Hillsboro | 1.79 | Wishek | .11 |
| Ohio | 37.7 | +9.8 | Middleport | 73 | 22 | 2 stations | 6 | 1 | 1.93 | −1.04 | Chilo | 6.93 | Lima | .70 |
| Oklahoma | 46.8 | +9.1 | Poteau | 78 | 19 | Kenton | 6 | 27 | 1.08 | −.41 | Hugo | 5.95 | 5 stations | T |
| Oregon | 30.8 | −.9 | 2 stations | 68 | [1]8 | Sand Creek | −23 | 17 | 4.83 | +1.02 | Tillamook | 22.52 | Hay Creek | .21 |
| Pennsylvania | 37.0 | +9.1 | do | 71 | 22 | 2 stations | −6 | 1 | 2.00 | −1.25 | Waynesburg | 3.43 | Lawrenceville | .54 |
| South Carolina | 51.4 | +5.5 | Calhoun Falls | 80 | 21 | Long Creek | 16 | [1]2 | 2.64 | −.92 | Beaufort (near) | 4.40 | Darlington | 1.07 |
| South Dakota | 25.9 | +10.5 | Spearfish | 63 | 28 | Pollock | −33 | 17 | .25 | −.34 | Hardy Ranger Station. | 2.18 | 2 stations | .00 |
| Tennessee | 46.2 | +7.2 | Savannah | 76 | 11 | Elkmont (2) | 11 | 1 | 3.46 | −1.27 | Newbern | 7.63 | Charleston | 1.64 |
| Texas | 53.8 | +5.6 | Riogrande | 89 | 17 | Romero | 11 | 27 | 1.80 | −.02 | Marshall | 8.68 | 11 stations | .00 |
| Utah | 22.6 | −2.3 | St. George | 61 | 15 | Castle Dale | −26 | 29 | 1.60 | +.32 | Silver Lake | 8.24 | 3 stations | .06 |
| Virginia | 43.6 | +7.8 | Diamond Springs | 78 | 23 | 2 stations | 11 | [1]1 | 3.38 | +.15 | Burkes Garden | 5.48 | Ivanhoe | 1.92 |
| Washington | 32.0 | +2.5 | 3 stations | 64 | [1]9 | Stockdills Ranch | −12 | 19 | 6.44 | +1.24 | Wynoochee Oxbow | 30.48 | Wahluke | .34 |
| West Virginia | 39.8 | +7.6 | Wardensville | 79 | 19 | Pickens | 1 | 1 | 3.74 | +.13 | Charleston | 6.41 | Upper Tract | 1.15 |
| Wisconsin | 25.1 | +10.0 | Viroqua | 55 | 6 | 2 stations | −27 | [1]12 | 1.22 | +.03 | Blair | 3.18 | P. K. Reservoir | .35 |
| Wyoming | 22.0 | +3.6 | Sheridan | 62 | 9 | Eden | −27 | 31 | .70 | −.20 | Bechler River | 11.41 | Dull Center (near) | .00 |
| Alaska (December) | 10.7 | +1.3 | Tree Point | 52 | 4 | Fort Yukon | −52 | [1]28 | 1.98 | −.69 | View Cove | 14.43 | 2 stations | .00 |
| Hawaii | 69.4 | +.7 | Mahukona | 90 | 5 | Kanalohuluhula | 40 | 11 | 10.45 | +1.30 | Puhonua | 45.60 | Launiupoko | .00 |
| Puerto Rico | 72.9 | −.1 | San German | 98 | 4 | Guineo Reservoir | 42 | 31 | 2.61 | −.97 | Rio Blanco | 9.18 | Yauco | .08 |

[1] Other dates also.

TABLE 1.—*Climatological data for Weather Bureau stations, January, 1933*

| District and station | Elevation of instruments: Barometer above sea level | Elevation of instruments: Thermometer above ground | Elevation of instruments: Anemometer above ground | Pressure: Station, reduced to mean of 24 hours | Pressure: Sea level, reduced to mean of 24 hours | Pressure: Departure from normal | Temperature of the air: Mean max. + mean min. ÷ 2 | Temperature of the air: Departure from normal | Temperature of the air: Maximum | Temperature of the air: Date | Temperature of the air: Mean maximum | Temperature of the air: Minimum | Temperature of the air: Date | Temperature of the air: Mean minimum | Temperature of the air: Greatest daily range | Mean wet thermometer | Mean temperature of the dew point | Mean relative humidity | Precipitation: Total | Precipitation: Departure from normal | Precipitation: Days with .01 or more | Wind: Total movement | Wind: Prevailing direction | Wind: Maximum velocity: Miles per hour | Wind: Maximum velocity: Direction | Wind: Maximum velocity: Date | Clear days | Partly cloudy days | Cloudy days | Average cloudiness, tenths | Total snowfall | Snow, sleet, and ice on ground at end of month |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *Ft.* | *Ft.* | *Ft.* | *In.* | *In.* | *In.* | °F. | °F. | °F. | | °F. | °F. | | °F. | °F. | °F. | °F. | % | *In.* | *In.* | | *Miles* | | | | | | | *0–10* | *In.* | *In.* |
| *New England* | | | | | | | | | | | | | | | | | | 75 | 2.17 | −1.3 | | | | | | | | | | 5.9 | | |
| | | | | | | | 34.2 | +9.7 | | | | | | | | | | | | | | | | | | | | | | | | |
| Eastport | 76 | 67 | 85 | 29.84 | 29.93 | −0.07 | 29.4 | +9.0 | 49 | 11 | 37 | 1 | 1 | 22 | 37 | 28 | 25 | 82 | 2.51 | −1.4 | 13 | 10,722 | nw. | 38 | sw. | 11 | 5 | 8 | 18 | 7.3 | 11.4 | 3.8 |
| Greenville, Me | 1,070 | 6 | ---- | 28.74 | 29.95 | ---- | 22.1 | ---- | 42 | 11 | 32 | −9 | 14 | 12 | 32 | ---- | ---- | ---- | 2.14 | ---- | 11 | 6,052 | se. | 30 | ---- | 23 | 9 | 8 | 14 | ---- | 22.8 | ---- |
| Portland, Me | 103 | 82 | 117 | 29.84 | 29.97 | −.08 | 32.2 | +9.8 | 55 | 17 | 39 | 7 | 1 | 25 | 28 | 28 | 23 | 73 | 5.40 | +1.4 | 9 | 7,872 | n. | 34 | nw. | 20 | 15 | 6 | 10 | 4.8 | 19.8 | 3.9 |
| Concord | 289 | 70 | 79 | 29.65 | 29.98 | −.07 | 30.8 | +9.2 | 55 | 4 | 39 | 2 | 1 | 22 | 33 | ---- | ---- | ---- | 1.95 | −1.0 | 9 | 5,065 | nw. | 24 | w. | 20 | 17 | 7 | 7 | 4.3 | 10.2 | T |
| Burlington | 403 | 11 | 48 | 29.53 | 29.99 | −.06 | 29.1 | +10.3 | 48 | 19 | 37 | −2 | 1 | 22 | 32 | ---- | ---- | ---- | .75 | −1.0 | 5 | 7,322 | s. | 41 | s. | 10 | 4 | 9 | 18 | 7.1 | 5.4 | 1.4 |
| Northfield | 876 | 12 | 60 | ---- | 29.99 | −.06 | 27.8 | +12.6 | 52 | 19 | 38 | −4 | 1 | 18 | 38 | ---- | ---- | 76 | 1.03 | −1.3 | 8 | 7,126 | s. | 31 | sw. | 7 | 6 | 7 | 18 | 7.5 | 7.0 | .3 |
| Boston | 125 | 106 | 165 | 29.84 | 29.98 | −.07 | 37.8 | +9.9 | 60 | 4 | 45 | 9 | 1 | 31 | 32 | 33 | 27 | 66 | 2.04 | −1.6 | 8 | 7,784 | nw. | 28 | nw. | 20 | 10 | 11 | 18 | 5.3 | 1.3 | .0 |
| Nantucket | 12 | 14 | 90 | 29.95 | 29.96 | −.08 | 39.3 | +8.0 | 56 | 23 | 45 | 20 | 1 | 33 | 23 | 36 | 33 | 82 | 2.73 | −1.0 | 11 | 13,640 | w. | 56 | ne. | 26 | 7 | 6 | 18 | 6.3 | .7 | .0 |
| Block Island | 26 | 11 | 46 | 29.95 | 29.98 | −.09 | 38.7 | +7.7 | 54 | 11 | 44 | 14 | 1 | 33 | 26 | 36 | 33 | 81 | 1.93 | −1.8 | 8 | 14,835 | sw. | 44 | nw. | 8 | 10 | 8 | 13 | 5.8 | .9 | T |
| Providence | 160 | 215 | 251 | 29.81 | 29.99 | −.07 | 37.4 | +10.2 | 59 | 23 | 44 | 12 | 1 | 30 | 28 | 32 | 26 | 67 | 2.02 | −1.7 | 9 | 10,065 | nw. | 47 | nw. | 20 | 13 | 7 | 11 | 5.0 | .1 | .0 |
| Hartford | 159 | 122 | ---- | 29.82 | 30.00 | −.07 | 36.6 | +11.1 | 57 | 19 | 44 | 10 | 1 | 29 | 28 | ---- | ---- | ---- | 1.73 | −2.2 | 10 | ---- | sw. | ---- | ---- | ---- | 10 | 9 | 12 | 5.5 | 5.0 | .0 |
| New Haven | 106 | 74 | 153 | 29.90 | 30.02 | −.06 | 37.2 | +9.0 | 59 | 23 | 44 | 11 | 1 | 30 | 29 | 33 | 29 | 74 | 1.73 | −2.2 | 7 | 7,885 | n. | 33 | n. | 26 | 12 | 4 | 15 | 5.5 | T | T |
| *Middle Atlantic States* | | | | | | | | | | | | | | | | | | 71 | 2.31 | −.9 | | | | | | | | | | 6.3 | | |
| | | | | | | | 41.6 | +9.4 | | | | | | | | | | | | | | | | | | | | | | | | |
| Albany | 97 | 107 | 115 | 29.91 | 30.02 | −.05 | 34.6 | +11.5 | 56 | 17 | 42 | 5 | 1 | 27 | 24 | 30 | 25 | 69 | 1.49 | −.9 | 7 | 6,529 | s. | 27 | se. | 19 | 6 | 12 | 13 | 6.2 | 3.7 | T |
| Binghamton | 871 | 60 | 68 | 29.07 | 30.02 | −.06 | 34.2 | +10.1 | 56 | 23 | 42 | 7 | 1 | 26 | 27 | ---- | ---- | ---- | 1.05 | −1.4 | 12 | 5,262 | nw. | 24 | sw. | 7 | 5 | 5 | 21 | 7.6 | 5.0 | T |
| New York | 314 | 414 | 454 | 29.67 | 30.02 | −.08 | 40.2 | +9.3 | 62 | 23 | 47 | 14 | 1 | 33 | 31 | 35 | 28 | 63 | 1.53 | −2.1 | 7 | 11,773 | nw. | 57 | nw. | 7 | 10 | 5 | 16 | 6.0 | T | .0 |
| Bellefonte | 1,050 | 5 | 42 | 28.89 | 30.03 | ---- | 34.9 | ---- | 62 | 19 | 44 | 8 | 1 | 26 | 30 | 30 | 26 | 76 | 1.72 | ---- | 11 | ---- | sw. | 38 | w. | 7 | 7 | 7 | 17 | 6.6 | 2.1 | .0 |
| Harrisburg | 374 | 94 | 104 | 29.63 | 30.04 | −.06 | 38.9 | +9.9 | 59 | 23 | 46 | 15 | 1 | 32 | 26 | 34 | 28 | 66 | 1.62 | −1.5 | 9 | 5,810 | nw. | 32 | w. | 7 | 9 | 7 | 15 | 6.2 | 1.9 | .0 |
| Philadelphia | 114 | 123 | 367 | 29.92 | 30.05 | −.06 | 42.6 | +10.0 | 63 | 23 | 49 | 17 | 1 | 36 | 25 | 36 | 29 | 62 | 2.66 | −.6 | 9 | 10,765 | sw. | 46 | n. | 26 | 10 | 6 | 15 | 6.0 | T | .0 |
| Reading | 323 | 283 | 304 | 29.69 | 30.05 | ---- | 40.8 | +11.4 | 60 | 23 | 48 | 14 | 1 | 33 | 27 | 34 | 28 | 64 | 1.21 | −2.4 | 9 | 5,559 | nw. | 38 | nw. | 7 | 8 | 9 | 14 | 6.0 | .4 | .0 |
| Scranton | 805 | 72 | 103 | 29.18 | 30.06 | −.03 | 35.3 | +8.7 | 55 | 19 | 42 | 9 | 1 | 28 | 24 | 32 | 28 | 76 | 1.12 | −1.9 | 10 | 5,358 | sw. | 27 | nw. | 7 | 6 | 10 | 15 | 6.1 | 5.2 | .0 |
| Atlantic City | 52 | 37 | 172 | 29.97 | 30.03 | −.08 | 42.5 | +10.0 | 64 | 23 | 49 | 19 | 1 | 36 | 23 | 38 | 34 | 75 | 3.37 | −.1 | 8 | 13,271 | nw. | 65 | ne. | 26 | 9 | 5 | 17 | 6.4 | T | .0 |
| Sandy Hook | 22 | 10 | 55 | 30.00 | 30.02 | ---- | 39.8 | ---- | 56 | 19 | 45 | 16 | 1 | 34 | 26 | 36 | 31 | 73 | 1.92 | −2.0 | 9 | 12,026 | nw. | 46 | ne. | 26 | 10 | 6 | 15 | 5.7 | T | .0 |
| Trenton | 190 | 159 | 183 | 29.83 | 30.04 | ---- | 39.6 | +9.1 | 61 | 23 | 47 | 14 | 1 | 32 | 28 | 35 | 30 | 73 | 1.93 | −1.4 | 9 | 8,024 | nw. | 37 | nw. | 29 | 9 | 6 | 16 | 6.0 | T | .0 |
| Baltimore | 123 | 100 | 215 | 29.91 | 30.05 | −.07 | 43.5 | +9.7 | 65 | 19 | 51 | 20 | 1 | 36 | 25 | 37 | 32 | 70 | 3.37 | −.1 | 6 | 8,183 | sw. | 43 | ne. | 26 | 11 | 5 | 15 | 5.9 | .1 | .0 |
| Washington | 112 | 62 | 85 | 29.94 | 30.06 | −.07 | 42.6 | +9.2 | 68 | 19 | 51 | 20 | 1 | 34 | 30 | 37 | 30 | 66 | 3.25 | −.3 | 9 | 5,648 | nw. | 30 | n. | 26 | 10 | 7 | 14 | 6.0 | T | .0 |
| Cape Henry | 18 | 8 | 54 | 30.03 | 30.05 | ---- | 48.5 | +8.3 | 75 | 22 | 55 | 31 | 1 | 42 | 25 | 44 | 40 | 77 | 3.04 | −.1 | 10 | 10,763 | sw. | 64 | n. | 26 | 6 | 10 | 15 | 6.6 | T | .0 |
| Lynchburg | 681 | 153 | 188 | 29.31 | 30.07 | −.06 | 45.4 | +7.9 | 68 | 22 | 54 | 21 | 2 | 36 | 34 | 40 | 34 | 67 | 2.73 | −.7 | 9 | 5,651 | w. | 31 | nw. | 28 | 11 | 8 | 12 | 5.6 | 3.1 | .0 |
| Norfolk | 91 | 170 | 205 | 29.97 | 30.07 | −.06 | 49.3 | +8.7 | 73 | 22 | 57 | 27 | 1 | 42 | 27 | 43 | 39 | 74 | 2.99 | −.1 | 9 | 10,268 | sw. | 43 | nw. | 26 | 6 | 9 | 16 | 6.9 | 1.4 | .0 |
| Richmond | 144 | 11 | 52 | 29.92 | 30.08 | −.06 | 45.6 | +7.7 | 72 | 22 | 55 | 21 | 2 | 36 | 34 | 40 | 36 | 76 | 3.85 | +.6 | 10 | 6,866 | sw. | 40 | n. | 26 | 7 | 9 | 15 | 6.5 | 1.7 | .0 |
| Wytheville | 2,304 | 49 | 55 | 27.67 | 30.10 | −.04 | 41.2 | +8.2 | 63 | 22 | 50 | 17 | 1 | 33 | 35 | 36 | 32 | 75 | 2.09 | −.1 | 10 | 5,730 | w. | 24 | w. | 22 | 8 | 8 | 15 | 6.5 | .3 | .0 |
| *South Atlantic States* | | | | | | | | | | | | | | | | | | 78 | 2.49 | −1.1 | | | | | | | | | | 6.1 | | |
| | | | | | | | 52.8 | +7.2 | | | | | | | | | | | | | | | | | | | | | | | | |
| Asheville | 2,253 | 89 | 104 | 27.72 | 30.12 | −.03 | 45.8 | +10.4 | 72 | 18 | 56 | 18 | 2 | 36 | 38 | 40 | 38 | 86 | 1.54 | −1.6 | 6 | 6,341 | nw. | 28 | nw. | 1 | 8 | 13 | 10 | 5.6 | .4 | .0 |
| Charlotte | 779 | 244 | 267 | 29.26 | 30.11 | −.04 | 49.2 | +8.0 | 72 | 21 | 56 | 26 | 1 | 42 | 23 | 44 | 38 | 70 | 1.37 | −2.6 | 8 | 8,974 | w. | 40 | w. | 27 | 7 | 8 | 16 | 6.2 | .4 | .0 |
| Greensboro | 886 | 5 | 56 | 29.13 | 30.10 | ---- | 45.6 | ---- | 72 | 21 | 56 | 15 | 2 | 36 | 33 | 40 | 36 | 79 | 2.65 | ---- | 6 | 6,404 | sw. | 29 | nw. | 25 | 6 | 9 | 16 | 6.6 | T | .0 |
| Hatteras | 11 | 5 | 50 | 30.04 | 30.05 | −.09 | 53.4 | +6.3 | 69 | 22 | 59 | 38 | 1 | 48 | 21 | 49 | 46 | 81 | 1.95 | −2.5 | 8 | 11,864 | n. | 49 | nw. | 26 | 6 | 10 | 15 | 6.3 | .0 | .0 |
| Raleigh | 376 | 103 | 146 | 29.72 | 30.09 | −.04 | 50.0 | +8.9 | 75 | 21 | 59 | 25 | 2 | 41 | 29 | 43 | 38 | 71 | 2.86 | −.8 | 6 | 7,182 | w. | 35 | nw. | 26 | 7 | 10 | 14 | 6.3 | 10.0 | .0 |
| Wilmington | 72 | 73 | 106 | 30.02 | 30.10 | −.04 | 53.6 | +7.1 | 74 | 21 | 62 | 31 | 16 | 45 | 30 | 47 | 44 | 79 | 2.22 | −1.1 | 5 | 7,417 | nw. | 38 | nw. | 26 | 9 | 12 | 10 | 5.5 | T | .0 |
| Charleston | 48 | 11 | 92 | 30.06 | 30.11 | −.04 | 55.8 | +5.9 | 75 | 21 | 64 | 35 | 14 | 48 | 24 | 50 | 46 | 79 | 3.85 | +.8 | 10 | 8,033 | sw. | 32 | nw. | 27 | 10 | 7 | 14 | 5.9 | .0 | .0 |
| Columbia, S. C | 351 | 41 | 57 | 29.73 | 30.12 | −.03 | 52.6 | +6.6 | 76 | 21 | 62 | 26 | 2 | 43 | 32 | 47 | 43 | 78 | 2.01 | −1.4 | 7 | 5,613 | sw. | 32 | sw. | 25 | 7 | 13 | 11 | 5.8 | .0 | .0 |
| Greenville, S. C | 1,039 | 139 | 146 | 28.99 | 30.10 | ---- | 49.7 | +9.4 | 72 | 20 | 57 | 26 | 2 | 42 | 24 | 44 | 39 | 74 | 2.86 | −2.0 | 7 | 6,977 | sw. | 35 | w. | 25 | 8 | 12 | 11 | 5.9 | .0 | .0 |
| Augusta | 182 | 62 | 77 | 29.92 | 30.11 | −.05 | 53.8 | +6.8 | 77 | 21 | 64 | 27 | 2 | 44 | 33 | 47 | 43 | 77 | 1.86 | −2.1 | 8 | 4,543 | nw. | 28 | nw. | 25 | 7 | 8 | 16 | 6.5 | .0 | .0 |
| Savannah | 65 | 73 | 152 | 30.05 | 30.12 | −.03 | 57.4 | +6.0 | 77 | 21 | 66 | 34 | 2 | 48 | 28 | 51 | 48 | 82 | 4.74 | +2.0 | 8 | 7,945 | n. | 40 | w. | 27 | 11 | 5 | 15 | 5.8 | .0 | .0 |
| Jacksonville | 43 | 209 | 245 | 30.07 | 30.12 | −.03 | 59.4 | +4.0 | 78 | 11 | 67 | 37 | 14 | 52 | 23 | 54 | 50 | 79 | 2.18 | −.6 | 8 | 7,978 | ne. | 38 | w. | 25 | 6 | 10 | 15 | 6.6 | .0 | .0 |
| *Florida Peninsula* | | | | | | | | | | | | | | | | | | 82 | .44 | −2.0 | | | | | | | | | | 5.4 | | |
| | | | | | | | 68.8 | +3.3 | | | | | | | | | | | | | | | | | | | | | | | | |
| Key West | 22 | 10 | 64 | 30.05 | 30.07 | −.03 | 72.0 | +2.5 | 82 | 13 | 77 | 55 | 30 | 67 | 22 | 66 | 64 | 82 | .28 | −1.7 | 4 | 7,145 | e. | 30 | nw. | 27 | 15 | 11 | 5 | 3.9 | .0 | .0 |
| Miami | 25 | 124 | 168 | 30.06 | 30.10 | −.03 | 70.1 | +3.6 | 82 | 25 | 76 | 44 | 29 | 64 | 25 | 64 | 61 | 78 | .57 | −2.0 | 6 | 7,195 | se. | 30 | nw. | 27 | 6 | 15 | 10 | 6.1 | .0 | .0 |
| Tampa | 35 | 88 | 197 | 30.06 | 30.10 | −.02 | 64.3 | +3.9 | 80 | 7 | 73 | 40 | 15 | 56 | 27 | 59 | 57 | 85 | .46 | −2.2 | 5 | 8,094 | e. | 34 | w. | 27 | 6 | 15 | 10 | 5.8 | .0 | .0 |
| Titusville | 44 | 5 | ---- | 30.04 | 30.09 | ---- | 64.5 | ---- | 82 | 7 | 73 | 40 | 29 | 56 | 29 | ---- | ---- | ---- | 1.97 | ---- | 8 | ---- | nw. | ---- | ---- | ---- | 9 | 14 | 8 | 5.6 | .0 | .0 |
| *East Gulf States* | | | | | | | | | | | | | | | | | | 78 | 3.44 | −1.3 | | | | | | | | | | 6.7 | | |
| | | | | | | | 54.8 | +6.7 | | | | | | | | | | | | | | | | | | | | | | | | |
| Atlanta | 1,173 | 190 | 198 | 28.87 | 30.13 | −.02 | 50.2 | +7.6 | 73 | 21 | 58 | 25 | 1 | 43 | 21 | 45 | 40 | 73 | 2.43 | −2.5 | 8 | 7,441 | nw. | 37 | w. | 25 | 7 | 10 | 14 | 6.1 | .0 | .0 |
| Macon | 370 | 76 | 84 | 29.73 | 30.14 | −.02 | 53.4 | +6.6 | 76 | 21 | 63 | 26 | 2 | 44 | 31 | 47 | 43 | 75 | 3.02 | −1.2 | 10 | 4,876 | nw. | 25 | nw. | 25 | 8 | 7 | 16 | 6.5 | .0 | .0 |
| Thomasville | 273 | 49 | 103 | 29.83 | 30.13 | −.03 | 57.8 | +6.8 | 79 | 8 | 67 | 31 | 1 | 49 | 28 | 51 | 48 | 80 | 4.46 | +.4 | 10 | 5,975 | ne. | 26 | nw. | 27 | 7 | 10 | 14 | 6.3 | .0 | .0 |
| Apalachicola | 36 | 11 | 51 | 30.08 | 30.12 | ---- | 57.6 | ---- | 72 | 25 | 63 | 35 | 1 | 52 | 21 | 54 | 52 | 87 | 5.88 | +2.2 | 9 | 6,053 | e. | 24 | n. | 12 | 8 | 5 | 18 | 6.9 | .0 | .0 |
| Pensacola | 56 | 149 | 185 | 30.06 | 30.12 | −.02 | 57.6 | +5.1 | 72 | 5 | 63 | 27 | 1 | 52 | 22 | 55 | 53 | 89 | 3.21 | −.8 | 10 | 8,495 | se. | 33 | w. | 27 | 7 | 4 | 20 | 7.1 | .0 | .0 |
| Anniston | 741 | 9 | 57 | ---- | ---- | ---- | 51.5 | +9.3 | 76 | 21 | 61 | 25 | 1 | 42 | 34 | ---- | ---- | ---- | 3.36 | ---- | 8 | ---- | sw. | ---- | ---- | ---- | 4 | 13 | 14 | ---- | .0 | .0 |
| Birmingham | 700 | 11 | 48 | 29.35 | 30.13 | −.03 | 51.8 | +6.7 | 70 | 18 | 60 | 21 | 1 | 44 | 29 | 46 | 42 | 74 | 3.09 | −2.4 | 8 | 5,601 | s. | 22 | nw. | 27 | 8 | 8 | 15 | 6.3 | .0 | .0 |
| Mobile | 57 | 125 | 161 | 30.06 | 30.12 | −.03 | 56.9 | +5.4 | 72 | 22 | 64 | 28 | 1 | 50 | 22 | 52 | 49 | 82 | 4.10 | −.8 | 11 | 6,338 | s. | 31 | nw. | 27 | 6 | 6 | 19 | 7.2 | .0 | .0 |
| Montgomery | 223 | 100 | 112 | 29.89 | 30.14 | −.02 | 55.2 | +7.0 | 76 | 20 | 63 | 28 | 1 | 47 | 28 | 49 | 44 | 73 | 3.23 | −2.0 | 10 | 5,162 | s. | 24 | nw. | 27 | 6 | 7 | 18 | 7.0 | .0 | .0 |
| Corinth | 469 | 6 | ---- | ---- | ---- | ---- | 49.9 | ---- | 75 | 19 | 60 | 19 | 1 | 40 | 37 | ---- | ---- | ---- | 3.18 | ---- | 10 | ---- | s. | ---- | ---- | ---- | 5 | 19 | 7 | ---- | .0 | .0 |
| Meridian | 375 | 87 | 95 | 29.72 | 30.12 | −.04 | 53.6 | +6.6 | 76 | 18 | 63 | 24 | 1 | 44 | 30 | 48 | 44 | 76 | 2.16 | −3.2 | 8 | 4,308 | s. | 24 | nw. | 27 | 8 | 6 | 17 | 6.6 | .0 | .0 |
| Vicksburg | 247 | 65 | 73 | 29.84 | 30.11 | −.04 | 55.2 | +7.0 | 77 | 20 | 63 | 27 | 1 | 47 | 23 | 49 | 45 | 74 | 2.63 | −2.7 | 8 | 6,034 | s. | 25 | w. | 26 | 8 | 4 | 19 | 6.7 | .0 | .0 |
| New Orleans | 53 | 76 | 84 | 30.06 | 30.12 | −.01 | 60.0 | +5.8 | 79 | 20 | 67 | 32 | 1 | 53 | 20 | 54 | 51 | 79 | 3.59 | −.8 | 14 | 4,766 | se. | 19 | e. | 30 | 5 | 8 | 18 | 7.1 | .0 | .0 |
| *West Gulf States* | | | | | | | | | | | | | | | | | | 74 | 2.66 | −.1 | | | | | | | | | | 6.4 | | |
| | | | | | | | 56.2 | +8.2 | | | | | | | | | | | | | | | | | | | | | | | | |
| Shreveport | 249 | 92 | 227 | 29.80 | 30.08 | −.06 | 55.6 | +8.6 | 76 | 23 | 63 | 31 | 1 | 48 | 26 | 50 | 46 | 75 | 2.85 | −1.1 | 11 | 8,496 | s. | 37 | nw. | 26 | 11 | 6 | 14 | 5.8 | .0 | .0 |
| Bentonville | 1,303 | 11 | 44 | 28.61 | 29.99 | −.15 | 45.8 | +11.7 | 67 | 24 | 56 | 16 | 12 | 36 | 33 | ---- | ---- | ---- | 3.80 | ---- | 9 | 5,866 | s. | 32 | sw. | 18 | 9 | 6 | 16 | ---- | .0 | .0 |
| Fort Smith | 457 | 79 | 94 | 29.53 | 30.02 | −.12 | 48.4 | +8.9 | 71 | 18 | 58 | 23 | 1 | 39 | 28 | 43 | 38 | 71 | 2.08 | −.5 | 12 | 6,318 | e. | 32 | sw. | 26 | 10 | 7 | 14 | 6.0 | T | .0 |
| Little Rock | 357 | 136 | 153 | 29.70 | 30.06 | −.09 | 50.2 | +8.8 | 72 | 21 | 58 | 22 | 1 | 42 | 29 | 44 | 37 | 65 | 3.30 | −1.4 | 12 | 6,309 | s. | 29 | w. | 26 | 8 | 5 | 18 | 6.7 | T | .0 |
| Austin | 605 | 136 | 148 | 29.40 | 30.04 | ---- | 58.1 | +8.6 | 80 | 23 | 68 | 22 | 1 | 49 | 36 | 51 | 46 | 70 | 5.10 | +3.0 | 14 | 5,878 | s. | 27 | nw. | 21 | 8 | 3 | 20 | 6.7 | .0 | .0 |
| Brownsville | 57 | 83 | 100 | 29.95 | 30.01 | ---- | 65.8 | +6.0 | 78 | 24 | 72 | 38 | 1 | 60 | 25 | 61 | 59 | 85 | .22 | −1.3 | 8 | 7,944 | se. | 32 | s. | 18 | 2 | 14 | 15 | 7.1 | .0 | .0 |
| Corpus Christi | 20 | 11 | 78 | 30.03 | 30.04 | −.06 | 62.4 | +6.4 | 78 | 24 | 68 | 41 | 1 | 57 | 23 | 59 | 57 | 88 | .70 | −.9 | 9 | 7,248 | se. | 30 | s. | 18 | 5 | 4 | 22 | 7.8 | .0 | .0 |
| Dallas | 512 | 220 | 227 | 29.50 | 30.05 | ---- | 53.8 | ---- | 73 | 24 | 62 | 28 | 12 | 45 | 26 | ---- | ---- | ---- | 2.67 | +.3 | 10 | 9,029 | se. | 47 | sw. | 26 | 12 | 8 | 11 | 4.9 | .0 | .0 |
| Fort Worth | 670 | 106 | 114 | 29.31 | 30.03 | −.09 | 54.6 | +9.2 | 75 | 24 | 65 | 29 | 13 | 44 | 32 | 47 | 40 | 65 | 1.96 | −.1 | 9 | 6,890 | s. | 26 | w. | 26 | 9 | 6 | 16 | 6.3 | .0 | .0 |
| Galveston | 54 | 106 | 114 | 30.01 | 30.07 | −.06 | 60.3 | +6.5 | 72 | 22 | 64 | 39 | 1 | 56 | 14 | 57 | 54 | 85 | 3.32 | −.1 | 14 | 7,591 | se. | 24 | nw. | 26 | 7 | 4 | 20 | 6.8 | .0 | .0 |
| Houston | 138 | 292 | 314 | 29.92 | 30.08 | ---- | 61.0 | +8.3 | 79 | 23 | 68 | 35 | 1 | 54 | 24 | ---- | ---- | ---- | 3.88 | +.2 | 12 | 9,334 | s. | 30 | s. | 18 | 9 | 1 | 21 | 6.9 | .0 | .0 |
| Palestine | 510 | 64 | 72 | 29.53 | 30.07 | −.05 | 55.7 | +7.5 | 75 | 23 | 64 | 25 | 1 | 47 | 27 | 49 | 43 | 69 | 3.26 | −.2 | 1 | 6,166 | s. | 25 | nw. | 26 | 10 | 6 | 15 | 6.3 | .0 | .0 |
| Port Arthur | 34 | 58 | 66 | 30.04 | 30.08 | ---- | 59.6 | ---- | 76 | 23 | 66 | 31 | 1 | 53 | 22 | ---- | ---- | ---- | 2.11 | −1.6 | 11 | 5,480 | s. | 24 | s. | 24 | 5 | 14 | 12 | 6.1 | .0 | .0 |
| San Antonio | 693 | 242 | 301 | 29.30 | 30.02 | −.08 | 60.0 | +7.7 | 79 | 23 | 68 | 30 | 1 | 52 | 29 | 53 | 47 | 69 | .66 | −.8 | 12 | 8,198 | se. | 38 | ne. | 11 | 9 | 5 | 17 | 6.5 | .0 | .0 |
| Taylor | 571 | 38 | 51 | 29.47 | 30.08 | −.03 | 56.4 | +8.9 | 78 | 23 | 66 | 24 | 1 | 47 | 32 | ---- | ---- | ---- | 5.13 | +3.2 | 11 | 6,209 | s. | 24 | s. | 20 | 8 | 6 | 17 | 6.1 | .0 | .0 |

TABLE 1.—*Climatological data for Weather Bureau stations, January, 1933*—Continued

| District and station | Elevation of instruments: Barometer above sea level | Elevation of instruments: Thermometer above ground | Elevation of instruments: Anemometer above ground | Pressure: Station, reduced to mean of 24 hours | Pressure: Sea level, reduced to mean of 24 hours | Pressure: Departure from normal | Temperature of the air: Mean daily max. + mean daily min. ÷ 2 | Temperature of the air: Departure from normal | Temperature of the air: Maximum | Temperature of the air: Date | Temperature of the air: Mean daily maximum | Temperature of the air: Minimum | Temperature of the air: Date | Temperature of the air: Mean daily minimum | Temperature of the air: Greatest daily range | Mean wet thermometer | Mean temperature of the dew point | Mean relative humidity | Precipitation: Total | Precipitation: Departure from normal | Precipitation: Days with .01 or more | Wind: Total movement | Wind: Prevailing direction | Wind: Maximum velocity: Miles per hour | Wind: Maximum velocity: Direction | Wind: Maximum velocity: Date | Clear days | Partly cloudy days | Cloudy days | Average cloudiness, tenths | Total snowfall | Snow, sleet, and ice on ground at end of month |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Ohio Valley and Tennessee* | *Ft.* | *Ft.* | *Ft.* | *In.* | *In.* | *In.* | *° F.* | *° F.* | *° F* | | *° F* | *° F.* | | *° F* | *° F.* | *° F.* | *° F.* | *%* | *In.* | *In.* | | *Miles* | | | | | | | | *0–10* | *In.* | *In.* |
| | | | | | | | 42.8 | +9.1 | | | | | | | | | | 74 | 2.99 | −.8 | | | | | | | | | | 6.4 | | |
| Chattanooga | 762 | 190 | 215 | 29.31 | 30.13 | −.03 | 48.5 | +7.3 | 69 | 23 | 56 | 25 | 1 | 41 | 29 | 43 | 38 | 69 | 2.80 | −2.5 | 9 | 5,859 | sw. | 35 | sw. | 25 | 5 | 12 | 14 | 6.5 | T | .0 |
| Knoxville | 995 | 79 | 97 | 29.03 | 30.11 | −.04 | 46.8 | +8.0 | 68 | 20 | 55 | 25 | 1 | 39 | 31 | 42 | 38 | 75 | 2.82 | −1.8 | 10 | 4,971 | sw. | 26 | w. | 27 | 7 | 7 | 17 | 6.9 | T | .0 |
| Memphis | 399 | 78 | 86 | 29.65 | 30.08 | −.08 | 50.3 | +9.4 | 73 | 20 | 57 | 24 | 1 | 44 | 22 | 45 | 40 | 71 | 2.33 | −2.5 | 11 | 6,319 | sw. | 31 | sw. | 24 | 9 | 8 | 14 | 6.0 | T | .0 |
| Nashville | 546 | 168 | 191 | 29.52 | 30.12 | −.04 | 47.0 | +8.4 | 70 | 22 | 56 | 21 | 1 | 38 | 32 | 43 | 39 | 79 | 3.51 | −1.2 | 11 | 7,307 | s. | 34 | nw. | 27 | 9 | 9 | 13 | 6.3 | .9 | .0 |
| Lexington | 989 | 193 | 230 | 29.01 | 30.10 | −.03 | 42.5 | +9.6 | 67 | 22 | 50 | 17 | 12 | 34 | 30 | | | | 6.52 | +2.3 | 13 | 10,485 | sw. | 41 | sw. | 22 | 15 | 4 | 12 | 5.2 | T | .0 |
| Louisville | 525 | 188 | 234 | 29.48 | 30.08 | −.06 | 43.1 | +8.7 | 69 | 22 | 51 | 20 | 12 | 35 | 31 | 40 | 36 | 76 | 4.63 | +.6 | 10 | 8,362 | s. | 36 | s. | 22 | 7 | 10 | 14 | 6.5 | T | .0 |
| Evansville | 431 | 76 | 116 | 29.58 | 30.06 | −.08 | 43.8 | +10.3 | 65 | 22 | 52 | 21 | 1 | 36 | 27 | 39 | 35 | 73 | 3.15 | −.6 | 11 | 7,823 | s. | 33 | sw. | 19 | 10 | 7 | 14 | 5.8 | T | .0 |
| Indianapolis | 822 | 194 | 230 | 29.12 | 30.02 | −.10 | 39.2 | +10.8 | 63 | 22 | 47 | 16 | 1 | 32 | 31 | 35 | 30 | 73 | 2.02 | −.9 | 9 | 8,825 | s. | 35 | sw. | 22 | 7 | 11 | 13 | 6.4 | .1 | .0 |
| Terre Haute | 575 | 96 | 129 | 29.39 | 30.02 | | 40.5 | | 63 | 22 | 48 | 15 | 1 | 32 | 30 | 36 | 32 | 76 | 2.29 | −.4 | 9 | 8,101 | s. | 35 | sw. | 22 | 11 | 7 | 13 | 5.9 | T | .0 |
| Cincinnati | 627 | 11 | 51 | 29.37 | 30.06 | −.06 | 40.6 | +10.3 | 69 | 22 | 49 | 17 | 12 | 33 | 32 | 37 | 33 | 76 | 3.18 | −.3 | 12 | 6,457 | s. | 32 | sw. | 22 | 9 | 7 | 15 | 6.5 | T | .0 |
| Columbus | 822 | 216 | 230 | 29.16 | 30.05 | −.06 | 38.6 | +10.0 | 67 | 22 | 46 | 16 | 1 | 31 | 29 | 35 | 31 | 75 | 1.36 | −1.7 | 7 | 9,476 | s. | 41 | sw. | 22 | 8 | 7 | 16 | 6.6 | .2 | .0 |
| Dayton | 899 | 137 | 173 | 29.07 | 30.05 | | 39.0 | +9.5 | 67 | 22 | 46 | 18 | 12 | 32 | 30 | 36 | 31 | 76 | 2.16 | −1.1 | 10 | 7,646 | sw. | 41 | sw. | 22 | 8 | 9 | 14 | 6.2 | T | .0 |
| Elkins | 1,947 | 59 | 67 | 28.00 | 30.12 | .00 | 38.6 | +8.2 | 69 | 22 | 48 | 11 | 1 | 29 | 35 | 33 | 28 | 75 | 2.79 | −1.0 | 15 | 4,874 | w. | 29 | w. | 7 | 7 | 8 | 16 | 6.7 | 2.2 | .0 |
| Parkersburg | 637 | 77 | 82 | 29.42 | 30.09 | −.03 | 41.6 | +9.1 | 71 | 22 | 50 | 18 | 1 | 33 | 27 | 36 | 32 | 73 | 2.96 | −.6 | 13 | 5,110 | se. | 24 | sw. | 7 | 7 | 7 | 17 | 6.8 | T | .0 |
| Pittsburgh | 842 | 353 | 410 | 29.13 | 30.06 | −.05 | 39.0 | +8.3 | 68 | 22 | 46 | 13 | 1 | 32 | 27 | 35 | 30 | 71 | 2.39 | −.7 | 10 | 8,570 | sw. | 40 | w. | 7 | 5 | 10 | 16 | 7.1 | .3 | .0 |
| *Lower Lake Region* | | | | | | | 35.2 | +10.8 | | | | | | | | | | 73 | 1.24 | −1.3 | | | | | | | | | | 7.3 | | |
| Buffalo | 767 | 243 | 280 | 29.13 | 29.98 | −.09 | 34.6 | +10.0 | 60 | 22 | 41 | 9 | 1 | 28 | 23 | 31 | 27 | 77 | 1.61 | −1.7 | 9 | 14,411 | sw. | 61 | w. | 19 | 4 | 10 | 17 | 7.2 | .7 | .1 |
| Canton | 448 | 10 | 61 | 29.46 | 29.96 | | 28.8 | +12.5 | 51 | 19 | 38 | −7 | 1 | 20 | 34 | | | | 1.51 | −1.0 | 11 | 8,658 | sw. | 38 | w. | 19 | 4 | 11 | 16 | 7.0 | 5.8 | 3.0 |
| Ithaca | 836 | 74 | 100 | 29.07 | 30.00 | | 35.2 | +10.9 | 63 | 19 | 43 | 9 | 1 | 27 | 29 | 30 | 24 | 67 | .44 | −1.8 | 7 | 9,142 | se. | 32 | w. | 7 | 3 | 8 | 20 | 7.7 | 1.3 | .0 |
| Oswego | 335 | 71 | 85 | 29.61 | 29.99 | −.08 | 33.9 | +10.0 | 58 | 19 | 41 | 5 | 1 | 27 | 30 | 30 | 25 | 72 | .89 | −2.0 | 6 | 9,381 | s. | 32 | w. | 20 | 2 | 6 | 23 | 8.1 | 4.0 | .0 |
| Rochester | 523 | 86 | 102 | 29.41 | 30.00 | −.07 | 35.6 | +11.0 | 61 | 19 | 42 | 9 | 1 | 29 | 30 | 31 | 24 | 65 | 1.38 | −1.5 | 11 | 8,083 | sw. | 39 | w. | 19 | 3 | 12 | 16 | 7.2 | 1.0 | .0 |
| Syracuse | 596 | 65 | 79 | 29.36 | 30.01 | −.06 | 36.0 | +13.0 | 63 | 19 | 43 | 9 | 1 | 29 | 33 | | | | 1.00 | −2.0 | 7 | 6,798 | s. | 28 | sw. | 23 | 3 | 6 | 22 | 8.1 | 1.4 | .0 |
| Erie | 714 | 130 | 166 | 29.22 | 30.00 | −.08 | 36.8 | +10.0 | 66 | 22 | 44 | 12 | 1 | 30 | 26 | 33 | 28 | 74 | 1.13 | −1.6 | 8 | 12,081 | s. | 47 | s. | 7 | 5 | 8 | 18 | 6.9 | .4 | .0 |
| Cleveland | 762 | 267 | 337 | 29.16 | 30.00 | −.09 | 38.0 | +11.5 | 68 | 22 | 45 | 15 | 1 | 31 | 32 | 33 | 28 | 69 | 1.40 | −1.1 | 9 | 11,637 | s. | 51 | sw. | 19 | 5 | 9 | 17 | 7.5 | 3.2 | .0 |
| Sandusky | 629 | 5 | 67 | 29.32 | 30.02 | −.07 | 36.8 | +10.5 | 66 | 22 | 44 | 13 | 1 | 29 | 28 | | | | 1.34 | −.9 | 7 | 8,303 | sw. | 35 | sw. | 19 | 4 | 9 | 18 | 7.2 | 1.0 | .0 |
| Toledo | 628 | 79 | 87 | 29.30 | 30.00 | −.09 | 35.8 | +10.0 | 65 | 22 | 43 | 13 | 1 | 29 | 25 | 32 | 28 | 75 | 1.13 | −1.0 | 8 | 8,136 | sw. | 41 | w. | 19 | 8 | 10 | 13 | 6.4 | 2.1 | T |
| Fort Wayne | 857 | 69 | 84 | 29.05 | 30.00 | | 36.2 | +9.3 | 62 | 22 | 44 | 16 | 12 | 29 | 29 | 33 | 29 | 77 | 1.83 | −.5 | 7 | 8,122 | s. | 35 | w. | 19 | 7 | 6 | 18 | 7.1 | .7 | .0 |
| Detroit | 730 | 218 | 258 | 29.18 | 29.99 | −.09 | 34.7 | +10.3 | 58 | 22 | 41 | 11 | 1 | 28 | 26 | 31 | 28 | 78 | 1.18 | −.9 | 7 | 8,745 | sw. | 47 | sw. | 19 | 5 | 6 | 20 | 7.2 | .4 | .0 |
| *Upper Lake Region* | | | | | | | 28.4 | +9.6 | | | | | | | | | | 82 | 1.49 | −.4 | | | | | | | | | | 7.6 | | |
| Alpena | 609 | 13 | 89 | 29.23 | 29.91 | −.13 | 28.0 | +8.9 | 50 | 19 | 36 | 2 | 30 | 20 | 30 | 26 | 23 | 85 | 1.17 | −.7 | 12 | 8,598 | nw. | 34 | nw. | 7 | 5 | 11 | 15 | 6.9 | 5.7 | T |
| Escanaba | 612 | 54 | 60 | 29.22 | 29.90 | −.15 | 23.3 | +7.9 | 40 | 6 | 31 | −3 | 12 | 16 | 31 | 22 | 19 | 83 | 2.06 | +.6 | 8 | 7,508 | n. | 31 | sw. | 1 | 5 | 7 | 19 | 7.2 | 5.5 | .5 |
| Grand Haven | 632 | 54 | 89 | 29.23 | 29.93 | −.14 | 32.9 | +8.6 | 54 | 22 | 39 | 11 | 29 | 28 | 26 | 31 | 29 | 85 | 1.51 | −.9 | 10 | 9,848 | s. | 41 | w. | 7 | 4 | 4 | 23 | 8.2 | 4.9 | .0 |
| Grand Rapids | 707 | 70 | 244 | 29.14 | 29.93 | −.13 | 34.0 | +9.5 | 56 | 22 | 41 | 12 | 12 | 27 | 30 | 31 | 27 | 77 | .87 | −1.5 | 11 | 10,424 | sw. | 50 | sw. | 19 | 2 | 7 | 22 | 8.2 | .8 | .0 |
| Houghton | 668 | 64 | 99 | 29.13 | 29.88 | −.17 | 20.8 | +6.1 | 43 | 6 | 29 | −7 | 12 | 13 | 37 | | | | 1.38 | −1.1 | 14 | 6,666 | w. | 35 | w. | 19 | 1 | 8 | 22 | 8.3 | 13.4 | 15.7 |
| Lansing | 878 | 6 | 88 | 28.99 | 29.96 | | 32.0 | +9.6 | 55 | 22 | 40 | 7 | 1 | 24 | 30 | 30 | 28 | 88 | 1.43 | −.4 | 10 | 8,514 | sw. | 34 | sw. | 19 | 3 | 10 | 18 | 7.4 | .8 | .0 |
| Ludington | 637 | 60 | 66 | 29.20 | 29.91 | | 31.7 | +8.6 | 48 | 22 | 38 | 11 | 12 | 26 | 29 | 30 | 27 | 83 | 1.19 | −.9 | 13 | 9,385 | s. | 40 | sw. | 1 | 6 | 7 | 18 | 6.9 | 4.9 | .0 |
| Marquette | 734 | 77 | 111 | 29.06 | 29.88 | −.16 | 24.0 | +7.7 | 43 | 21 | 31 | −3 | 12 | 17 | 33 | 22 | 19 | 84 | 2.11 | −.2 | 19 | 7,766 | w. | 34 | s. | 14 | 3 | 4 | 24 | 8.3 | 15.5 | 5.6 |
| Port Huron | 638 | 79 | 120 | 29.25 | 29.96 | −.10 | 33.0 | +10.7 | 59 | 22 | 40 | 7 | 1 | 27 | 23 | 30 | 27 | 81 | 1.11 | −.7 | 8 | 9,745 | sw. | 41 | sw. | 19 | 3 | 9 | 19 | 7.5 | .3 | .0 |
| Sault Sainte Marie | 614 | 11 | 52 | 29.19 | 29.91 | −.12 | 22.6 | +9.3 | 43 | 6 | 30 | −12 | 29 | 15 | 31 | 21 | 19 | 87 | 2.23 | +.3 | 17 | 6,623 | e. | 31 | w. | 19 | 3 | 4 | 24 | 8.4 | 16.8 | 3.9 |
| Chicago | 673 | 7 | 131 | 29.22 | 29.96 | −.14 | 36.7 | +13.0 | 57 | 18 | 43 | 16 | 12 | 30 | 28 | 33 | 28 | 72 | 2.32 | +.4 | 7 | 9,143 | sw. | 35 | w. | 19 | 8 | 6 | 17 | 6.7 | .9 | .0 |
| Green Bay | 617 | 109 | 141 | 29.21 | 29.89 | −.17 | 27.6 | +11.9 | 51 | 6 | 35 | 0 | 12 | 20 | 27 | 25 | 21 | 76 | 1.43 | −.1 | 7 | 8,919 | s. | 38 | s. | 1 | 3 | 5 | 23 | 7.9 | 2.8 | .0 |
| Milwaukee | 681 | 97 | 221 | 29.17 | 29.92 | −.16 | 33.7 | +13.1 | 52 | 6 | 41 | 8 | 12 | 27 | 27 | 30 | 26 | 76 | 1.30 | −.5 | 5 | 10,289 | w. | 43 | w. | 19 | 3 | 12 | 16 | 7.3 | 1.5 | T |
| Duluth | 1,133 | 5 | 47 | 28.60 | 29.86 | −.23 | 17.6 | +9.7 | 42 | 15 | 27 | −15 | 12 | 9 | 36 | 16 | 14 | 90 | .74 | −.2 | 13 | 9,157 | w. | 32 | nw. | 11 | 4 | 6 | 21 | 7.6 | 11.4 | 5.3 |
| *North Dakota* | | | | | | | 12.6 | +7.6 | | | | | | | | | | 86 | .77 | +.3 | | | | | | | | | | 6.3 | | |
| Moorhead | 940 | 50 | 58 | 28.81 | 29.88 | −.26 | 11.9 | +8.1 | 41 | 10 | 22 | −10 | 20 | 2 | 45 | 12 | 10 | 92 | 1.37 | +.7 | 14 | 6,924 | s. | 30 | n. | 10 | 8 | 8 | 15 | 6.7 | 20.8 | 12.2 |
| Bismarck | 1,674 | 8 | 57 | 28.00 | 29.86 | −.27 | 14.2 | +6.4 | 52 | 9 | 25 | −20 | 17 | 4 | 44 | 13 | 10 | 82 | .83 | +.4 | 8 | 5,852 | nw. | 34 | nw. | 6 | 9 | 8 | 14 | 6.1 | 12.5 | 7.8 |
| Devils Lake | 1,478 | 11 | 44 | 28.22 | 29.87 | −.25 | 9.5 | +7.7 | 39 | 10 | 19 | −13 | 31 | 0 | 44 | 8 | 6 | 91 | .88 | +.4 | 10 | 7,429 | w. | 32 | se. | 28 | 9 | 3 | 19 | 6.7 | 9.8 | 6.4 |
| Ellendale | 1,457 | 10 | 56 | 28.23 | 29.85 | | 15.2 | | 46 | 9 | 26 | −23 | 17 | 4 | 41 | | | | .26 | −.2 | 6 | 9,453 | nw. | 42 | nw. | 10 | 8 | 10 | 13 | 6.1 | 4.7 | 1.4 |
| Grand Forks | 833 | 12 | 67 | | | | 9.4 | | 40 | 10 | 20 | −14 | 13 | −1 | 43 | 7 | | | 1.06 | | 10 | | se. | 47 | nw. | 11 | 7 | 14 | 10 | | 11.6 | 13.8 |
| Williston | 1,878 | 41 | 48 | 27.78 | 29.84 | −.27 | 14.8 | +8.4 | 49 | 9 | 26 | −15 | 31 | 4 | 43 | 13 | 9 | 79 | .49 | .0 | 8 | 5,415 | sw. | 38 | w. | 9 | 9 | 8 | 14 | 5.9 | 5.1 | 4.1 |
| *Upper Mississippi Valley* | | | | | | | 34.6 | +13.2 | | | | | | | | | | 76 | 1.75 | +.2 | | | | | | | | | | 6.3 | | |
| Minneapolis | 918 | 102 | 208 | 28.84 | 29.86 | | 23.1 | +10.4 | 46 | 6 | 32 | −5 | 14 | 14 | 40 | | | | .89 | .0 | 14 | 8,218 | w. | 33 | w. | 19 | 3 | 8 | 20 | 7.4 | 4.1 | 1.0 |
| St. Paul | 837 | 114 | 149 | 28.93 | 29.86 | −.25 | 23.0 | +10.4 | 44 | 6 | 32 | −9 | 14 | 15 | 43 | | | | 1.28 | +.4 | 14 | 6,793 | s. | 30 | w. | 19 | 3 | 12 | 16 | 7.0 | 6.7 | 2.2 |
| La Crosse | 714 | 11 | 48 | 29.09 | 29.89 | −.22 | 28.6 | +12.5 | 52 | 6 | 38 | −6 | 14 | 20 | 36 | 26 | 23 | 82 | 1.44 | +.4 | 8 | 4,581 | s. | 18 | s. | 1 | 4 | 13 | 14 | 7.1 | 3.7 | .0 |
| Madison | 974 | 70 | 78 | 28.83 | 29.92 | −.18 | 30.8 | +14.1 | 52 | 16 | 39 | 4 | 12 | 23 | 28 | 28 | 24 | 80 | .72 | −.7 | 6 | 7,574 | s. | 27 | w. | 19 | 2 | 13 | 16 | 7.2 | 2.0 | T |
| Wausau | 1,247 | 4 | 62 | 28.52 | 29.90 | | 23.6 | | 47 | 6 | 32 | −5 | 12 | 16 | 30 | | | | 3.02 | +1.8 | 16 | 5,446 | w. | 27 | w. | 10 | 5 | 3 | 23 | 7.5 | 12.8 | 4.1 |
| Charles City | 1,015 | 10 | 51 | 28.79 | 29.90 | −.24 | 28.9 | +15.2 | 51 | 6 | 38 | −4 | 14 | 20 | 38 | 26 | 23 | 83 | 1.03 | .0 | 6 | 6,020 | se. | 25 | w. | 19 | 13 | 3 | 15 | 5.8 | .7 | .0 |
| Davenport | 606 | 118 | 143 | 29.27 | 29.95 | −.17 | 36.4 | +14.6 | 55 | 16 | 45 | 11 | 14 | 28 | 27 | 32 | 27 | 74 | 1.87 | +.4 | 8 | 9,278 | sw. | 41 | w. | 19 | 7 | 11 | 13 | 6.1 | 1.1 | .0 |
| Des Moines | 861 | 5 | 99 | 28.99 | 29.92 | −.22 | 34.2 | +14.1 | 55 | 15 | 44 | 10 | 14 | 25 | 31 | 30 | 26 | 75 | 1.06 | .0 | 8 | 7,692 | s. | 31 | w. | 19 | 10 | 6 | 15 | 6.0 | 2.3 | T |
| Dubuque | 700 | 81 | 96 | 29.15 | 29.92 | −.20 | 33.0 | +13.9 | 54 | 16 | 42 | 7 | 14 | 24 | 27 | 30 | 25 | 76 | .58 | −.7 | 4 | 5,762 | s. | 23 | nw. | 7 | 6 | 9 | 16 | 6.6 | 1.1 | T |
| Keokuk | 614 | 64 | 78 | 29.29 | 29.98 | −.16 | 39.4 | +14.5 | 61 | 21 | 48 | 14 | 14 | 30 | 29 | 34 | 28 | 67 | 1.87 | +.3 | 9 | 7,077 | sw. | 29 | w. | 19 | 10 | 10 | 11 | 5.7 | .6 | .0 |
| Cairo | 358 | 87 | 93 | 29.67 | 30.06 | −.10 | 45.8 | +10.9 | 65 | 18 | 54 | 20 | 1 | 38 | 24 | 41 | 37 | 74 | 3.78 | .0 | 11 | 7,396 | s. | 28 | sw. | 22 | 8 | 9 | 14 | 6.3 | T | .0 |
| Peoria | 609 | 11 | 45 | 29.31 | 29.99 | −.13 | 37.6 | +14.5 | 59 | 16 | 46 | 16 | 1 | 29 | 28 | 33 | 29 | 78 | 1.69 | −.1 | 11 | 6,525 | s. | 27 | w. | 22 | 10 | 10 | 11 | 5.7 | .6 | .0 |
| Springfield, Ill | 636 | 5 | 191 | 29.30 | 29.99 | −.14 | 39.6 | +13.1 | 62 | 21 | 48 | 15 | 1 | 31 | 26 | 35 | 32 | 77 | 2.85 | +.8 | 8 | 9,681 | s. | 34 | nw. | 27 | 6 | 17 | 8 | 6.2 | T | .0 |
| Hannibal | 534 | 74 | 109 | 29.40 | 29.99 | −.14 | 40.8 | +13.7 | 64 | 21 | 50 | 18 | 11 | 32 | 31 | | | | 1.96 | +.2 | 8 | 7,699 | sw. | 30 | sw. | 10 | 9 | 13 | 9 | 5.5 | .2 | .0 |
| St. Louis | 568 | 265 | 303 | 29.39 | 30.00 | −.14 | 43.6 | +12.8 | 66 | 21 | 52 | 20 | 1 | 35 | 28 | 38 | 32 | 69 | 2.18 | −.2 | 9 | 10,573 | sw. | 44 | sw. | 10 | 11 | 10 | 10 | 5.1 | T | .0 |

TABLE 1.—*Climatological data for Weather Bureau stations, January, 1933*—Continued

| District and station | Elevation of instruments: Barometer above sea level | Elevation of instruments: Thermometer above ground | Elevation of instruments: Anemometer above ground | Pressure: Station, reduced to mean of 24 hours | Pressure: Sea level, reduced to mean of 24 hours | Pressure: Departure from normal | Temperature of the air: Mean max. + mean min. ÷ 2 | Temperature of the air: Departure from normal | Temperature of the air: Maximum | Temperature of the air: Date | Temperature of the air: Mean maximum | Temperature of the air: Minimum | Temperature of the air: Date | Temperature of the air: Mean minimum | Temperature of the air: Greatest daily range | Mean wet thermometer | Mean temperature of the dew point | Mean relative humidity | Precipitation: Total | Precipitation: Departure from normal | Precipitation: Days with .01 or more | Wind: Total movement | Wind: Prevailing direction | Wind: Maximum velocity: Miles per hour | Wind: Maximum velocity: Direction | Wind: Maximum velocity: Date | Clear days | Partly cloudy days | Cloudy days | Average cloudiness, tenths | Total snowfall | Snow, sleet, and ice on ground at end of month |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Ft. | Ft. | Ft. | In. | In. | In. | °F. | °F. | °F | | °F | °F. | | °F | °F. | °F. | °F. | % | In. | In. | | Miles | | | | | | | | 0-10 | In. | In. |
| *Missouri Valley* | | | | | | | 36.2 | +13.3 | | | | | | | | | | 66 | .77 | −.2 | | | | | | | | | | 4.7 | | |
| Columbia, Mo | 784 | 6 | 84 | 29.15 | 30.00 | −.13 | 42.1 | +12.9 | 65 | 21 | 52 | 18 | 12 | 32 | 32 | | | | 1.87 | .0 | 8 | 7,396 | sw. | 31 | sw. | 10 | 12 | 12 | 7 | 4.7 | T | .0 |
| Kansas City | 963 | 10 | 86 | 28.91 | 29.97 | −.18 | 42.4 | +14.2 | 67 | 21 | 52 | 19 | 11 | 33 | 30 | 36 | 29 | 62 | 1.20 | .0 | 7 | 7,381 | s. | 31 | nw. | 11 | 14 | 14 | 3 | 3.7 | 2.5 | .0 |
| St. Joseph | 967 | 11 | 49 | 28.88 | 29.94 | | 40.1 | | 68 | 21 | 50 | 16 | 11 | 30 | 34 | 33 | 27 | 64 | .37 | −.7 | 4 | 7,159 | sw. | 31 | nw. | 10 | 15 | 11 | 5 | 3.9 | 1.0 | .0 |
| Springfield, Mo | 1,324 | 98 | 104 | 28.58 | 30.00 | −.14 | 44.3 | +10.8 | 66 | 18 | 53 | 19 | 12 | 36 | 26 | 38 | 31 | 65 | 2.68 | +.3 | 6 | 8,601 | s. | 31 | nw. | 26 | 14 | 7 | 10 | 4.4 | T | .0 |
| Iola | 984 | 11 | 50 | 28.91 | 29.97 | −.17 | 43.0 | +13.2 | 64 | 21 | 55 | 12 | 12 | 31 | 33 | | | | 1.36 | .0 | 5 | | s. | | | | 15 | 8 | 8 | | .0 | .0 |
| Topeka | 987 | 92 | 107 | | | | 41.4 | +13.8 | 67 | 21 | 52 | 17 | 11 | 30 | 33 | | | | .17 | −.8 | 3 | 7,378 | sw. | 28 | n. | 11 | 18 | 11 | 2 | 3.1 | 1.0 | .0 |
| Lincoln | 1,189 | 11 | 81 | 28.62 | 29.92 | −.23 | 36.6 | +13.8 | 60 | 6 | 48 | 8 | 17 | 26 | 35 | 31 | 24 | 66 | .37 | −.3 | 5 | 7,423 | s. | 30 | nw. | 11 | 13 | 9 | 9 | 4.7 | .2 | .0 |
| Omaha | 1,105 | 115 | 122 | 28.71 | 29.92 | −.23 | 36.2 | +14.3 | 59 | 6 | 46 | 10 | 17 | 26 | 37 | 31 | 24 | 63 | .94 | +.2 | 6 | 6,294 | nw. | 29 | nw. | 10 | 14 | 4 | 13 | 5.2 | 1.9 | T |
| Valentine | 2,598 | 47 | 54 | 27.12 | 29.90 | −.22 | 31.3 | +12.4 | 59 | 9 | 45 | −2 | 16 | 18 | 39 | 25 | 18 | 64 | .09 | −.4 | 4 | 7,405 | w. | 38 | nw. | 6 | 9 | 13 | 9 | 5.3 | 1.0 | T |
| Sioux City | 1,135 | 94 | 164 | 28.64 | 29.89 | −.26 | 31.4 | +13.6 | 56 | 6 | 41 | 2 | 17 | 22 | 38 | 28 | 23 | 71 | .40 | −.3 | 6 | 8,656 | nw. | 41 | nw. | 19 | 9 | 11 | 11 | 5.6 | .6 | .0 |
| Huron | 1,306 | 59 | 74 | 28.44 | 29.88 | −.28 | 25.5 | +14.2 | 52 | 21 | 36 | −9 | 17 | 14 | 35 | 22 | 18 | 79 | .18 | −.4 | 4 | 7,613 | se. | 38 | w. | 10 | 11 | 13 | 7 | 5.2 | .6 | .2 |
| Pierre | 1,572 | 70 | 75 | 28.15 | 29.86 | −.27 | 28.2 | +12.2 | 55 | 14 | 40 | −10 | 17 | 17 | 33 | 23 | 16 | 64 | .03 | −.4 | 2 | 6,141 | nw. | 40 | nw. | 6 | 10 | 14 | 7 | 5.2 | .4 | .0 |
| Yankton | 1,233 | 49 | 57 | 28.54 | 29.89 | −.27 | 31.6 | +14.3 | 56 | 20 | 43 | 1 | 17 | 20 | 39 | | | | .38 | −.2 | 1 | 6,519 | w. | 31 | w. | 6 | 8 | 12 | 11 | 5.8 | 2.0 | 2.0 |
| *Northern Slope* | | | | | | | 25.4 | +6.1 | | | | | | | | | | 68 | .61 | −.2 | | | | | | | | | | 5.9 | | |
| Billings | 3,140 | 5 | | | | | 23.6 | | 56 | 9 | 38 | −26 | 17 | 9 | 46 | | | | 1.14 | | 5 | | nw. | | | | 8 | 4 | 19 | | 12.7 | 6.0 |
| Havre | 2,505 | 11 | 67 | 27.10 | 29.81 | −.29 | 21.6 | +8.7 | 53 | 9 | 32 | −21 | 17 | 11 | 43 | 17 | 14 | 77 | .35 | −.4 | 4 | 7,937 | sw. | 41 | sw. | 9 | 4 | 14 | 13 | 6.4 | 4.6 | 1.1 |
| Helena | 4,124 | 89 | 113 | 25.58 | 29.87 | −.28 | 26.2 | +6.0 | 51 | 9 | 34 | −8 | 17 | 18 | 36 | 22 | 16 | 65 | .55 | −.3 | 6 | 6,932 | sw. | 38 | sw. | 11 | 2 | 8 | 21 | 7.7 | 9.1 | T |
| Kalispell | 2,973 | 48 | 56 | 26.74 | 29.87 | −.25 | 26.4 | +6.0 | 49 | 9 | 33 | −1 | 17 | 20 | 25 | 25 | 23 | 86 | 1.10 | −.5 | 17 | 4,551 | nw. | 25 | sw. | 9 | 1 | 9 | 21 | 8.2 | 12.9 | 3.0 |
| Miles City | 2,371 | 48 | 55 | 27.27 | 29.90 | −.22 | 20.4 | +5.9 | 57 | 9 | 31 | −23 | 17 | 10 | 42 | 18 | 14 | 79 | 1.35 | +.7 | 5 | 4,124 | s. | 29 | w. | 6 | 13 | 7 | 11 | 5.0 | 15.5 | 7.2 |
| Rapid City | 3,259 | 50 | 58 | 26.38 | 29.88 | −.22 | 30.6 | +8.6 | 61 | 9 | 43 | −10 | 17 | 18 | 41 | 25 | 17 | 60 | .06 | −.4 | 3 | 6,078 | w. | 34 | nw. | 6 | 7 | 16 | 8 | 5.3 | 1.1 | .0 |
| Cheyenne | 6,088 | 84 | 101 | 23.81 | 29.90 | −.15 | 29.3 | +3.8 | 52 | 9 | 39 | 6 | 11 | 19 | 30 | 22 | 9 | 42 | .24 | −.2 | 1 | 12,619 | w. | 65 | w. | 18 | 13 | 15 | 3 | 4.4 | 4.0 | T |
| Lander | 5,372 | 60 | 68 | 24.44 | 29.94 | −.18 | 22.0 | +3.7 | 55 | 9 | 36 | −13 | 17 | 8 | 37 | 19 | 14 | 72 | .42 | −.1 | 4 | 4,535 | s. | 49 | sw. | 6 | 21 | 10 | 0 | 2.6 | 5.3 | 2.1 |
| Sheridan | 3,790 | 10 | 47 | 25.88 | 29.88 | | 23.4 | | 62 | 9 | 37 | −18 | 17 | 10 | 39 | 20 | 13 | 65 | .67 | −.2 | 7 | 4,581 | nw. | 35 | nw. | 6 | 10 | 13 | 8 | 5.4 | 8.6 | 3.3 |
| Yellowstone Park | 6,241 | 11 | 48 | 23.68 | 29.98 | −.16 | 19.2 | +1.6 | 36 | 9 | 25 | −7 | 16 | 13 | 30 | 17 | 13 | 75 | 1.19 | −.4 | 18 | 8,610 | sw. | 35 | sw. | 2 | 0 | 4 | 27 | 9.2 | 23.3 | 9.5 |
| North Platte | 2,821 | 11 | 51 | 26.92 | 29.92 | −.20 | 33.2 | +10.3 | 60 | 9 | 47 | 10 | 30 | 20 | 40 | 25 | 17 | 62 | .16 | −.2 | 1 | 5,506 | w. | 25 | nw. | 6 | 11 | 11 | 9 | 4.9 | 1.3 | 1.3 |
| *Middle Slope* | | | | | | | 40.1 | +9.6 | | | | | | | | | | 51 | .10 | −.5 | | | | | | | | | | 3.7 | | |
| Denver | 5,292 | 106 | 113 | 24.55 | 29.88 | −.17 | 36.0 | +6.2 | 65 | 9 | 47 | 14 | 27 | 25 | 35 | 27 | 12 | 40 | .01 | −.4 | 1 | 6,008 | s. | 32 | w. | 18 | 16 | 13 | 2 | 3.7 | .2 | .0 |
| Pueblo | 4,685 | 80 | 86 | 25.15 | 29.89 | −.16 | 37.0 | +7.1 | 65 | 9 | 51 | 8 | 30 | 23 | 52 | 27 | 11 | 37 | .00 | −.3 | 0 | 6,561 | w. | 40 | w. | 18 | 18 | 11 | 2 | 3.5 | .0 | .0 |
| Concordia | 1,392 | 50 | 58 | 28.45 | 29.95 | −.19 | 38.6 | +12.2 | 62 | 21 | 50 | 15 | 11 | 27 | 35 | 31 | 24 | 63 | .19 | −.4 | 4 | 6,238 | sw. | 25 | sw. | 10 | 15 | 12 | 4 | 3.7 | T | .0 |
| Dodge City | 2,509 | 10 | 86 | 27.31 | 29.96 | −.15 | 38.8 | +9.8 | 64 | 21 | 54 | 14 | 27 | 24 | 41 | 29 | 17 | 48 | T. | −.4 | 0 | 8,674 | sw. | 38 | sw. | 21 | 23 | 4 | 4 | 2.5 | .0 | .0 |
| Wichita | 1,358 | 85 | 93 | 28.50 | 29.96 | −.17 | 42.5 | +11.2 | 65 | 21 | 53 | 21 | 12 | 32 | 31 | 35 | 26 | 58 | .10 | −.7 | 2 | 8,586 | sw. | 35 | sw. | 21 | 14 | 10 | 7 | 4.2 | .0 | .0 |
| Oklahoma City | 1,214 | 10 | 47 | 28.68 | 29.98 | −.13 | 47.5 | +11.1 | 71 | 21 | 59 | 19 | 12 | 36 | 36 | 39 | 31 | 59 | .33 | −.9 | 4 | 7,405 | s. | 30 | sw. | 21 | 11 | 13 | 7 | 4.7 | .0 | .0 |
| *Southern Slope* | | | | | | | 48.4 | +5.7 | | | | | | | | | | 58 | .23 | −.4 | | | | | | | | | | 4.6 | | |
| Abilene | 1,738 | 10 | 52 | 28.20 | 30.02 | −.07 | 52.0 | +7.8 | 80 | 18 | 64 | 26 | 12 | 40 | 34 | 43 | 34 | 58 | .34 | −.6 | 2 | 7,386 | s. | 34 | w. | 24 | 13 | 4 | 14 | 5.3 | .0 | .0 |
| Amarillo | 3,676 | 10 | 49 | 26.19 | 29.97 | −.09 | 43.8 | +8.5 | 66 | 3 | 57 | 21 | 12 | 31 | 39 | 32 | 18 | 42 | .02 | −.5 | 2 | 7,734 | sw. | 40 | sw. | 21 | 19 | 9 | 3 | 3.2 | .0 | .0 |
| Big Spring | 2,537 | 5 | 62 | 27.38 | 30.03 | | 48.4 | | 73 | 21 | 61 | 24 | 13 | 36 | 39 | 40 | 33 | 66 | .19 | | 3 | | s. | | | | 14 | 9 | 8 | 4.6 | .0 | .0 |
| Del Rio | 944 | 64 | 71 | 29.00 | 30.00 | −.06 | 56.7 | +4.4 | 83 | 21 | 67 | 27 | 1 | 46 | 32 | 50 | 44 | 69 | .40 | −.2 | 9 | 5,659 | se. | 27 | nw. | 24 | 8 | 5 | 18 | 6.3 | .0 | .0 |
| Roswell | 3,566 | 75 | 85 | 26.34 | 30.01 | −.03 | 41.2 | +2.0 | 65 | 15 | 56 | 15 | 1 | 27 | 41 | 33 | 22 | 53 | .15 | −.4 | 2 | 5,351 | nw. | 39 | nw. | 26 | 20 | 6 | 5 | 3.4 | .0 | .0 |
| *Southern Plateau* | | | | | | | 37.8 | −2.9 | | | | | | | | | | 59 | 1.15 | +.5 | | | | | | | | | | 3.6 | | |
| El Paso | 3,778 | 152 | 175 | 26.19 | 30.04 | +.03 | 43.7 | −1.3 | 65 | 10 | 56 | 24 | 1 | 32 | 33 | 36 | 26 | 52 | .19 | −.3 | 3 | 6,792 | nw. | 38 | nw. | 21 | 15 | 11 | 5 | 3.5 | T | .0 |
| Albuquerque | 4,972 | 51 | 66 | 25.04 | 30.07 | | 32.4 | | 54 | 10 | 45 | 10 | 1 | 20 | 38 | 26 | 17 | 57 | .08 | | 3 | 4,126 | ne. | 35 | nw. | 26 | 15 | 7 | 9 | 4.2 | .6 | .0 |
| Santa Fe | 7,013 | 38 | 53 | 23.17 | 30.08 | +.04 | 27.2 | −1.6 | 48 | 9 | 37 | 9 | 1 | 17 | 26 | 22 | 15 | 60 | .73 | +.1 | 6 | 4,777 | ne. | 21 | nw. | 21 | 15 | 11 | 5 | 3.8 | 7.8 | 1.0 |
| Flagstaff | 6,907 | 10 | 59 | 23.26 | 30.02 | −.03 | 23.0 | −3.7 | 53 | 9 | 36 | −7 | 29 | 10 | 47 | 20 | | 81 | 2.06 | | 11 | 6,845 | sw. | 32 | ne. | 11 | 15 | 6 | 10 | | 24.0 | 13.5 |
| Phoenix | 1,108 | 10 | 107 | 28.84 | 30.02 | −.01 | 48.6 | −2.6 | 75 | 9 | 62 | 20 | 2 | 36 | 37 | 40 | 29 | 54 | 2.31 | +1.5 | 6 | 3,936 | e. | 32 | sw. | 17 | 15 | 8 | 8 | 4.0 | 1.0 | .0 |
| Yuma | 141 | 9 | 54 | 29.88 | 30.04 | −.01 | 51.1 | −3.3 | 76 | 9 | 63 | 34 | 29 | 40 | 35 | 43 | 30 | 48 | 1.16 | +.7 | 5 | 4,814 | n. | 31 | nw. | 11 | 23 | 4 | 4 | 2.3 | .0 | .0 |
| Independence | 3,957 | 6 | 27 | 25.95 | 30.07 | .00 | 33.3 | −4.9 | 64 | 6 | 46 | −1 | 18 | 20 | 39 | 25 | | | 1.38 | +.5 | 5 | | nw. | | | | 19 | 1 | 11 | | 20.0 | 6.0 |
| *Middle Plateau* | | | | | | | 25.5 | −2.7 | | | | | | | | | | 74 | 1.47 | +.4 | | | | | | | | | | 5.4 | | |
| Reno | 4,532 | 74 | 81 | 25.39 | 30.03 | −.10 | 30.3 | −2.2 | 62 | 9 | 42 | 9 | 30 | 19 | 41 | 27 | 20 | 64 | 2.22 | +.7 | 12 | 4,804 | w. | 29 | sw. | 9 | 12 | 6 | 13 | 5.1 | 28.5 | 6.9 |
| Tonopah | 6,090 | 12 | 20 | | | | 26.4 | | 55 | 9 | 33 | 9 | 18 | 20 | 21 | 23 | 19 | 76 | 1.00 | | 8 | | se. | | | | | | | | | |
| Winnemucca | 4,344 | 18 | 56 | 25.56 | 30.05 | −.11 | 26.1 | −2.5 | 55 | 9 | 38 | 3 | 25 | 14 | 40 | 24 | 20 | 79 | 1.14 | +.1 | 12 | 6,173 | sw. | 27 | sw. | 24 | 10 | 7 | 14 | 5.8 | 15.4 | 6.4 |
| Modena | 5,473 | 10 | 46 | 24.55 | 30.05 | −.05 | 21.8 | −4.9 | 52 | 9 | 34 | −7 | 31 | 9 | 41 | 19 | 16 | 80 | 1.38 | +.5 | 11 | 6,947 | sw. | 38 | s. | 15 | 15 | 4 | 12 | 5.0 | 20.6 | 9.6 |
| Salt Lake City | 4,360 | 163 | 203 | 25.57 | 30.03 | −.12 | 29.0 | −.2 | 47 | 9 | 36 | 14 | 29 | 22 | 29 | 26 | 20 | 68 | 2.07 | +.8 | 11 | 5,257 | s. | 30 | se. | 17 | 8 | 6 | 17 | 6.6 | 22.9 | 12.0 |
| Grand Junction | 4,602 | 60 | 68 | 25.38 | 30.08 | +.02 | 20.2 | −3.8 | 44 | 15 | 32 | −6 | 2 | 8 | 44 | 18 | 14 | 80 | .54 | −.1 | 9 | 3,514 | nw. | 28 | sw. | 15 | 14 | 9 | 8 | 4.6 | 4.5 | 2.3 |
| *Northern Plateau* | | | | | | | 31.8 | +3.3 | | | | | | | | | | 72 | 1.32 | −.3 | | | | | | | | | | 7.7 | | |
| Baker | 3,471 | 48 | 53 | 26.34 | 30.01 | −.15 | 22.7 | −2.2 | 47 | 5 | 32 | −7 | 18 | 14 | 32 | 22 | 18 | 77 | 1.91 | +.5 | 16 | 5,253 | se. | 22 | w. | 5 | 3 | 9 | 19 | 7.5 | 17.1 | 7.9 |
| Boise | 2,739 | 79 | 87 | 27.12 | 30.04 | −.15 | 31.8 | +2.0 | 48 | 6 | 38 | 14 | 26 | 25 | 22 | 28 | 24 | 72 | 1.08 | −.6 | 13 | 5,096 | se. | 25 | se. | 29 | 3 | 5 | 23 | 8.3 | 15.1 | 8.0 |
| Lewiston | 757 | 40 | 48 | 29.10 | 29.93 | −.23 | 37.2 | +4.7 | 57 | 4 | 44 | 18 | 17 | 31 | 22 | | | | 1.35 | −.2 | 9 | 3,978 | e. | 27 | sw. | 5 | 2 | 7 | 22 | 8.1 | 3.3 | 1.0 |
| Pocatello | 4,477 | 60 | 68 | 25.38 | 30.02 | −.18 | 26.9 | +2.2 | 45 | 9 | 33 | 4 | 21 | 20 | 29 | 24 | 20 | 76 | 1.85 | +.5 | 16 | 9,115 | se. | 38 | sw. | 10 | 2 | 13 | 16 | 7.5 | 20.0 | 10.3 |
| Spokane | 1,929 | 101 | 110 | 27.79 | 29.88 | −.24 | 31.8 | +4.3 | 48 | 8 | 37 | 11 | 18 | 27 | 19 | 29 | 26 | 77 | 1.16 | −1.0 | 14 | 6,468 | s. | 26 | sw. | 5 | 0 | 9 | 22 | 8.1 | 15.7 | 7.3 |
| Walla Walla | 991 | 57 | 65 | 28.82 | 29.91 | −.24 | 39.1 | +6.4 | 61 | 8 | 45 | 13 | 17 | 33 | 23 | 34 | 27 | 62 | 1.28 | −.7 | 13 | 6,007 | s. | 30 | w. | 5 | 1 | 12 | 18 | 7.8 | 1.5 | .0 |
| Yakima | 1,076 | 58 | 67 | 28.72 | 29.89 | | 33.0 | +5.6 | 59 | 8 | 42 | 9 | 19 | 25 | 26 | 30 | 24 | 71 | .62 | −.7 | 8 | 3,959 | nw. | 32 | nw. | 5 | 5 | 9 | 17 | 6.8 | 8.0 | 1.7 |
| *North Pacific Coast Region* | | | | | | | 40.0 | −.4 | | | | | | | | | | 84 | 7.65 | +1.3 | | | | | | | | | | 8.6 | | |
| North Head | 211 | 11 | 56 | 29.65 | 29.88 | −.17 | 40.2 | −1.9 | 49 | 8 | 44 | 29 | 17 | 37 | 13 | 39 | 37 | 89 | 13.14 | +4.4 | 27 | 13,466 | s. | 65 | s. | 24 | 1 | 7 | 23 | 8.5 | 10.2 | .0 |
| Port Angeles | 29 | 8 | 53 | | 29.85 | | 38.8 | | 51 | 7 | 44 | 27 | 16 | 34 | 14 | | | | 4.35 | −.2 | 17 | 5,208 | s. | 28 | sw. | 9 | 1 | 8 | 22 | | 1.3 | .0 |
| Seattle | 125 | 215 | 250 | 29.72 | 29.86 | −.19 | 39.6 | +.1 | 53 | 8 | 43 | 28 | 17 | 36 | 12 | 37 | 34 | 82 | 5.20 | +.3 | 21 | 8,468 | s. | 38 | sw. | 9 | 1 | 4 | 26 | 8.8 | 1.1 | .0 |
| Tacoma | 194 | 172 | 201 | 29.67 | 29.88 | −.16 | 39.6 | +.8 | 55 | 8 | 44 | 25 | 18 | 35 | 15 | | | | 5.84 | −.3 | 23 | 7,841 | s. | 37 | sw. | 9 | 0 | 7 | 24 | 8.7 | 7.3 | .0 |
| Tatoosh Island | 86 | 9 | 53 | 29.70 | 29.80 | −.24 | 40.8 | −.4 | 49 | 8 | 43 | 32 | 18 | 38 | 8 | 38 | 36 | 84 | 13.20 | +1.4 | 25 | 13,146 | s. | 54 | s. | 8 | 0 | 7 | 24 | 8.6 | 1.4 | .0 |
| Medford | 1,329 | 29 | 58 | 28.59 | 30.04 | | 34.8 | | 50 | 13 | 42 | 15 | 22 | 28 | 27 | 33 | 31 | 84 | 3.36 | +.6 | 16 | 3,875 | n. | 35 | se. | 24 | 3 | 6 | 22 | 8.0 | 11.3 | .0 |
| Portland, Oreg | 153 | 68 | 106 | 29.78 | 29.94 | −.14 | 39.8 | +.4 | 58 | 8 | 44 | 23 | 18 | 36 | 13 | 38 | 35 | 83 | 7.94 | +1.3 | 26 | 6,142 | s. | 25 | s. | 1 | 1 | 4 | 26 | 8.8 | 8.7 | .0 |
| Roseburg | 510 | 75 | 99 | 29.45 | 30.01 | −.09 | 39.8 | −1.4 | 58 | 6 | 46 | 25 | 17 | 34 | 18 | 38 | 35 | 82 | 8.16 | +2.8 | 22 | 3,848 | s. | 21 | s. | 24 | 1 | 7 | 23 | 8.6 | 8.3 | .0 |

TABLE 1.—*Climatological data for Weather Bureau stations, January, 1933*—Continued

| District and station | Elevation of instruments: Barometer above sea level | Elevation of instruments: Thermometer above ground | Elevation of instruments: Anemometer above ground | Pressure: Station, reduced to mean of 24 hours | Pressure: Sea level, reduced to mean of 24 hours | Pressure: Departure from normal | Temperature of the air: Mean max. + mean min. ÷ 2 | Temperature of the air: Departure from normal | Temperature of the air: Maximum | Temperature of the air: Date | Temperature of the air: Mean maximum | Temperature of the air: Minimum | Temperature of the air: Date | Temperature of the air: Mean minimum | Temperature of the air: Greatest daily range | Mean wet thermometer | Mean temperature of the dew point | Mean relative humidity | Precipitation: Total | Precipitation: Departure from normal | Precipitation: Days with .01, or more | Wind: Total movement | Wind: Prevailing direction | Wind: Maximum velocity: Miles per hour | Wind: Maximum velocity: Direction | Wind: Maximum velocity: Date | Clear days | Partly cloudy days | Cloudy days | Average cloudiness, tenths | Total snowfall | Snow, sleet, and ice on ground at end of month |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *Ft.* | *Ft.* | *Ft.* | *In.* | *In.* | *In.* | °*F.* | °*F.* | °*F.* | | °*F.* | °*F.* | | °*F.* | °*F.* | °*F.* | °*F.* | % | *In.* | *In.* | | *Miles* | | | | | | | | *0-10* | *In.* | *In.* |
| *Middle Pacific Coast Region* | | | | | | | 43.9 | −3.5 | | | | | | | | | | 80 | 4.76 | +.1 | | | | | | | | | | 6.3 | | |
| Eureka | 62 | 73 | 89 | 30.00 | 30.07 | −.03 | 43.6 | −3.3 | 64 | 13 | 50 | 28 | 17 | 37 | 25 | 42 | 40 | 87 | 7.04 | −.1 | 18 | 5,516 | se. | 27 | n. | 10 | 7 | 8 | 16 | 6.2 | T | .0 |
| Red Bluff | 330 | 5 | 58 | 29.68 | 30.05 | −.07 | 42.7 | −3.1 | 73 | 13 | 51 | 29 | 16 | 35 | 38 | 39 | 34 | 75 | 4.09 | −.7 | 13 | 5,805 | nw. | 35 | se. | 24 | 7 | 9 | 15 | 6.4 | 4.1 | .0 |
| Sacramento | 69 | 106 | 117 | 29.99 | 30.07 | −.05 | 42.0 | −3.8 | 61 | 13 | 48 | 30 | 17 | 36 | 25 | 40 | 37 | 81 | 2.85 | −.9 | 12 | 6,364 | se. | 34 | se. | 18 | 8 | 7 | 16 | 6.5 | T | .0 |
| San Francisco | 155 | 208 | 243 | 29.88 | 30.05 | −.06 | 47.0 | −2.9 | 65 | 13 | 52 | 36 | 10 | 42 | 22 | 44 | 40 | 79 | 5.68 | +1.1 | 14 | 5,499 | se. | 28 | s. | 24 | 10 | 6 | 15 | 5.8 | .0 | .0 |
| San Jose | 141 | 12 | 110 | 29.92 | 30.08 | ..... | 44.0 | −4.3 | 66 | 13 | 52 | 27 | 17 | 36 | 35 | ..... | ..... | ..... | 4.12 | +1.1 | 12 | 4,839 | se. | 24 | se. | 22 | 6 | 9 | 16 | 6.5 | .0 | .0 |
| *South Pacific Coast Region* | | | | | | | 50.1 | −1.6 | | | | | | | | | | 68 | 4.99 | +2.7 | | | | | | | | | | 5.1 | | |
| Fresno | 327 | 89 | 98 | 29.74 | 30.10 | .00 | 43.0 | −3.2 | 63 | 14 | 50 | 32 | 12 | 36 | 26 | 40 | 36 | 79 | 2.18 | +.4 | 11 | 4,319 | nw. | 23 | nw. | 27 | 4 | 8 | 19 | 7.4 | .0 | .0 |
| Los Angeles | 338 | 159 | 191 | 29.68 | 30.04 | −.04 | 54.4 | −.2 | 81 | 9 | 63 | 40 | 24 | 46 | 29 | 45 | 35 | 57 | 8.46 | +5.4 | 12 | 4,762 | ne. | 25 | se. | 19 | 18 | 5 | 8 | 3.6 | .0 | .0 |
| San Diego | 87 | 62 | 70 | 29.95 | 30.04 | −.03 | 52.8 | −1.5 | 71 | 14 | 61 | 39 | 20 | 45 | 25 | 46 | 40 | 67 | 4.32 | +2.3 | 12 | 4,752 | e. | 32 | se. | 16 | 15 | 6 | 10 | 4.3 | .0 | .0 |
| *West Indies* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| San Juan, P. R | 82 | 9 | 54 | 29.92 | 30.01 | ..... | 75.3 | +.3 | 85 | 29 | 80 | 66 | 18 | 70 | 17 | ..... | ..... | ..... | 2.30 | −1.8 | 18 | 8,622 | e. | 29 | e. | 2 | 9 | 22 | 0 | 4.6 | .0 | .0 |
| *Panama Canal* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Balboa Heights | 118 | 6 | 97 | ..... | [1] 29.83 | −.01 | 79.2 | −.7 | 90 | 7 | 87 | 67 | 29 | 71 | 21 | ..... | ..... | [1] 79 | 1.63 | +.8 | 4 | 5,356 | nw. | 21 | nw. | 25 | 10 | 18 | 3 | 5.0 | .0 | .0 |
| Cristobal | 36 | 6 | 97 | ..... | [1] 29.85 | −.01 | 80.6 | −.9 | 87 | 28 | 84 | 72 | 28 | 77 | 15 | 73 | 72 | [1] 78 | 2.10 | −1.4 | 18 | 9,503 | n. | 28 | n. | 3 | 6 | 17 | 8 | 5.6 | .0 | .0 |
| *Alaska* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Fairbanks | 455 | 11 | 44 | [2] 29.30 | [2] 29.89 | ..... | 23.5 | ..... | 17 | 16 | −14 | −60 | 28 | −33 | 35 | −22 | −26 | 81 | 1.13 | ..... | 12 | 1,531 | n. | 17 | sw. | 21 | 14 | 5 | 12 | 5.0 | 18.3 | 23.2 |
| Juneau | 80 | 11 | 50 | [2] 29.48 | [2] 29.57 | ..... | 24.0 | ..... | 45 | 12 | 28 | 7 | 3 | 20 | 17 | 22 | 16 | 72 | 6.01 | ..... | 26 | 6,440 | s. | 27 | ne. | 1 | 2 | 4 | 25 | 8.8 | 40.5 | 9.5 |
| *Hawaiian Islands* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Honolulu | 38 | 86 | 100 | [2] 29.99 | [2] 30.03 | ..... | 72.4 | ..... | 80 | 5 | 77 | 65 | 22 | 68 | 13 | 65 | 62 | 72 | 2.63 | −1.2 | 18 | 8,964 | e. | 29 | e. | 24 | 8 | 13 | 10 | 5.6 | .0 | .0 |

[1] Observations taken bihourly.

[2] Pressure not reduced to mean of 24 hours.

TABLE 2.—*Data furnished by the Canadian Meteorological Service, January, 1933*

| Stations | Altitude above mean sea level, Jan. 1, 1919 | Pressure: Station reduced to mean of 24 hours | Pressure: Sea level reduced to mean of 24 hours | Pressure: Departure from normal | Temperature of the air: Mean max.+ mean min.÷2 | Temperature of the air: Departure from normal | Temperature of the air: Mean maximum | Temperature of the air: Mean minimum | Temperature of the air: Highest | Temperature of the air: Lowest | Precipitation: Total | Precipitation: Departure from normal | Precipitation: Total snowfall |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *Feet* | *In.* | *In.* | *In.* | °*F.* | °*F.* | °*F.* | °*F.* | °*F.* | °*F.* | *In.* | *In.* | *In.* |
| Cape Race, N. F | 99 | ..... | ..... | ..... | ..... | ..... | ..... | 19.7 | ..... | 4 | 4.97 | ..... | 0.5 |
| Sydney, C. B. I | 48 | 29.92 | 29.97 | +0.04 | 28.2 | +7.7 | 36.0 | 20.4 | 50 | 10 | 6.75 | +1.65 | 17.5 |
| Halifax, N. S | 88 | 29.79 | 29.90 | −.07 | 30.2 | +8.4 | 38.3 | 22.2 | 52 | 9 | 5.12 | −.65 | 8.1 |
| Yarmouth, N. S | 65 | 29.79 | 29.86 | −.14 | 32.4 | +6.1 | 39.3 | 25.6 | 49 | 12 | 4.28 | −.88 | 12.2 |
| Charlottetown, P. E. I | 38 | 29.80 | 29.84 | −.08 | 25.4 | +8.4 | 32.6 | 18.1 | 45 | 2 | 3.77 | −.19 | 26.7 |
| Chatham, N. B | 28 | 29.78 | 29.82 | −.15 | 19.6 | +9.8 | 29.2 | 10.0 | 46 | −9 | 2.37 | −1.22 | 19.8 |
| Father Point, Que | 20 | 29.87 | 29.90 | −.08 | 18.3 | +10.3 | 27.0 | 9.6 | 42 | −6 | 4.02 | +1.17 | 40.2 |
| Quebec, Que | 296 | 29.61 | 29.95 | −.07 | 20.4 | +11.3 | 28.0 | 12.8 | 42 | −11 | 3.04 | −.97 | 22.6 |
| Doucet, Que | 1,236 | ..... | ..... | ..... | 7.0 | ..... | 20.5 | −6.4 | 36 | −44 | 4.27 | ..... | 39.6 |
| Montreal, Que | 187 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| Ottawa, Ont | 236 | 29.67 | 29.95 | −.08 | 25.4 | +15.8 | 33.9 | 17.0 | 46 | −10 | 1.67 | −1.32 | 4.6 |
| Kingston, Ont | 285 | 29.65 | 29.97 | −.08 | 31.4 | +14.3 | 38.1 | 24.8 | 50 | −3 | .94 | −2.51 | .4 |
| Toronto, Ont | 379 | 29.54 | 29.97 | −.08 | 33.6 | +12.2 | 40.0 | 27.2 | 55 | 5 | 1.62 | −1.30 | 2.1 |
| Cochrane, Ont | 930 | ..... | ..... | ..... | 6.2 | ..... | 16.7 | −4.3 | 34 | −29 | 2.03 | ..... | 20.1 |
| White River, Ont | 1,244 | 28.51 | 29.89 | −.12 | 6.0 | +6.4 | 19.2 | −7.2 | 35 | −44 | 1.57 | −.12 | 15.7 |
| London, Ont | 808 | ..... | ..... | ..... | 32.1 | ..... | 38.9 | 25.3 | 56 | 7 | 1.36 | ..... | 1.8 |
| Southampton, Ont | 656 | 29.19 | 29.92 | −.11 | 30.0 | +9.6 | 37.0 | 23.0 | 54 | 9 | 1.90 | −2.15 | 9.0 |
| Parry Sound, Ont | 688 | 29.21 | 29.93 | −.08 | 25.5 | +11.7 | 33.0 | 18.0 | 44 | −7 | 1.61 | −2.47 | 5.5 |
| Port Arthur, Ont | 644 | 29.15 | 29.89 | −.18 | 13.2 | +10.1 | 22.1 | 4.4 | 38 | −2.6 | 1.10 | +.28 | 11.0 |
| Winnipeg, Man | 760 | 28.99 | 29.88 | −.23 | 2.3 | +10.1 | 12.0 | −7.3 | 33 | −31 | 1.04 | +.16 | 10.4 |
| Minnedosa, Man | 1,690 | 27.94 | 29.85 | −.25 | 1.7 | +8.9 | 11.1 | −7.7 | 39 | −30 | .86 | +.06 | 8.6 |
| Le Pas, Man | 860 | ..... | ..... | ..... | −7.6 | ..... | 1.4 | −16.5 | 36 | −38 | .83 | ..... | 8.3 |
| Qu'Appelle, Sask | 2,115 | 27.42 | 29.78 | −.30 | 3.9 | +7.7 | 13.6 | −5.7 | 38 | −31 | .80 | +.30 | T |
| Moose Jaw, Sask | 1,759 | ..... | ..... | ..... | 8.5 | ..... | 20.2 | −3.2 | 45 | −26 | .36 | ..... | 3.6 |
| Swift Current, Sask | 2,392 | 27.12 | 29.75 | −.34 | 13.8 | +10.7 | 26.5 | 1.1 | 46 | −16 | .59 | −.05 | 5.0 |
| Medicine Hat, Alb | 2,365 | 27.14 | 29.68 | −.39 | 18.9 | +13.4 | 30.0 | 7.8 | 51 | 12 | .54 | −.08 | 5.4 |
| Calgary, Alb | 3,540 | 25.90 | 29.69 | −.34 | 16.5 | +8.1 | 28.1 | 4.9 | 52 | −15 | .42 | −.11 | 4.2 |
| Banff, Alb | 4,521 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| Prince Albert, Sask | 1,450 | 28.21 | 29.87 | −.22 | −4.0 | +4.4 | 7.0 | −14.9 | 38 | −38 | .96 | −.01 | 9.6 |
| Battleford, Sask | 1,592 | 27.99 | 29.83 | −.25 | −1.9 | +4.0 | 8.0 | −11.7 | 39 | −38 | .40 | .00 | 4.0 |
| Edmonton, Alb | 2,150 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| Kamloops, B. C | 1,262 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| Victoria, B. C | 230 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| Barkerville, B. C | 4,180 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| Estevan Point, B. C | 20 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| Prince Rupert, B. C | 170 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| Hamilton, Ber | 151 | 29.87 | 30.03 | −.10 | 66.4 | +4.4 | 71.3 | 61.5 | 77 | 48 | 5.88 | +9.4 | .0 |

**LATE REPORTS FOR DECEMBER, 1932**

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Moose Jaw, Sask | 1,759 | ..... | ..... | ..... | 11.8 | ..... | 21.3 | 2.2 | 45 | −28 | .50 | ..... | 5.0 |

## SEVERE LOCAL STORMS, JANUARY, 1933

[Compiled by Mary O. Souder]

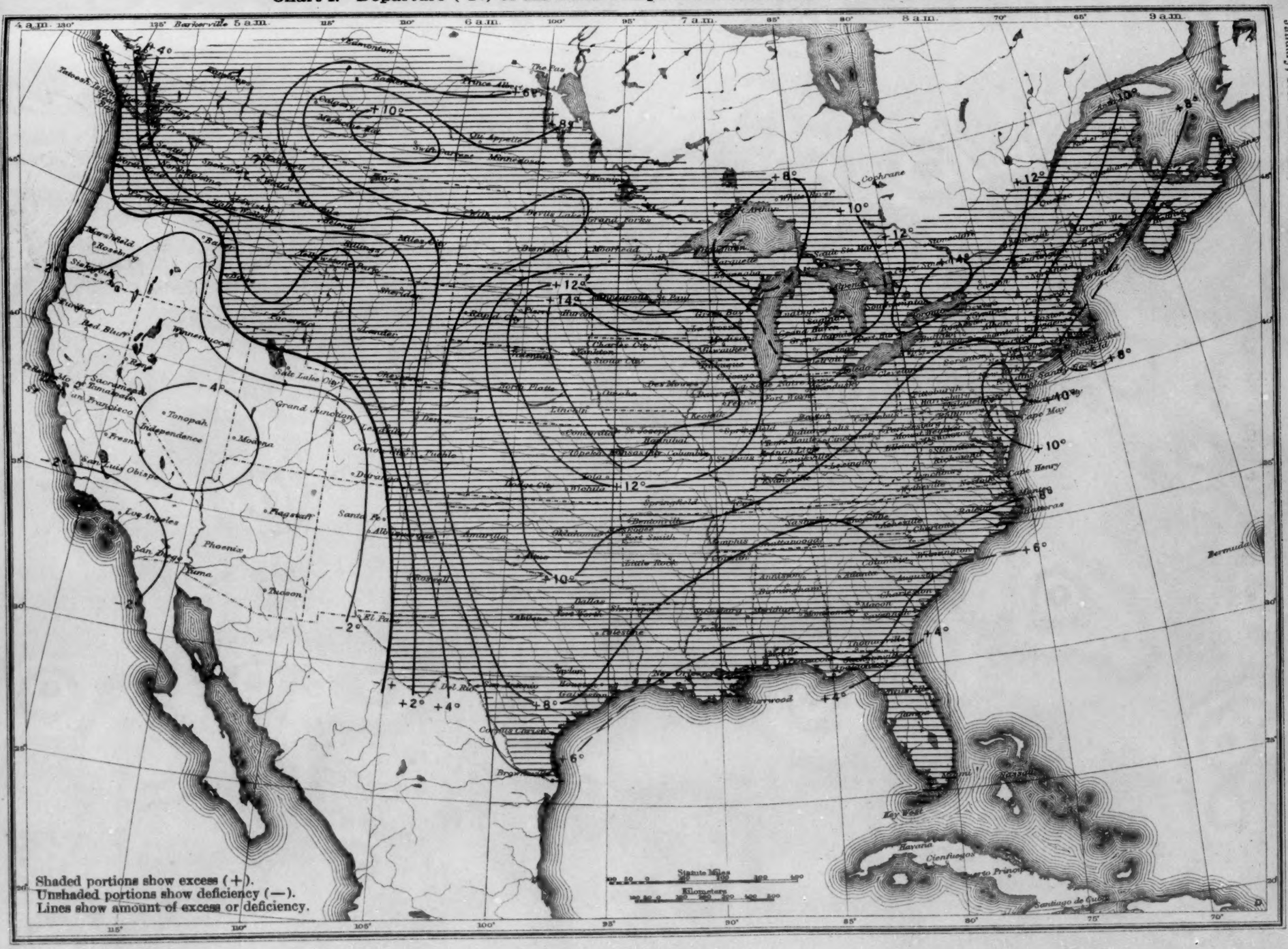
[The table herewith contains such data as have been received concerning severe local storms that occurred during the month. A revised list of tornadoes will appear in the Annual Report of the Chief of Bureau]

| Place | Date | Time | Width of path (yards) | Loss of life | Value of property destroyed | Character of storm | Remarks | Authority |
|---|---|---|---|---|---|---|---|---|
| North Carolina, central and northern counties. | 13 | | | | | Rain, sleet, and snow. | No details | Official, U. S. Weather Bureau. |
| Booneville, Ark. | 18 | | | | | Heavy hail | Considerable damage to roofs of buildings and tops of automobiles. | Do. |
| Durango, Colo. | 18 | | | | | Wind and snow | Train service discontinued; 18 persons were snowbound on highways. | Do. |
| Colorado, northeastern counties. | 18 | P. m. | | | | Wind | Electric wires damaged; railroad and automobile traffic interrupted; winter wheat crop damaged by shifting soil. | Do. |
| Cheyenne County, Nebr. | 18 | do | [1] 30 | | | do | Damage to property and considerable damage to winter wheat not estimated; path 30 miles long. | Do. |
| Cheyenne, Wyo., and vicinity. | 18 | do | | | $19,432 | do | Rail transportation delayed; highway and air traffic paralyzed; large property loss. | Do. |
| Tulare and Los Angeles Counties, Calif. | 19 | | | | | Ice storm | Communication lines and trees damaged | Do. |
| Michigan (southeastern) | 19 | | | | 1,000,000 | Tornadic winds | Wires and telephone poles blown down; all traffic delayed; property damaged; several persons injured. | Do. |
| Madison, Wis. | 19 | | | | 500 | Gale | No details reported | Do. |
| Milwaukee, Wis. | 19 | A. m. | | | 4,000 | do | Power lines and property damaged; one person injured. | Do. |
| Sidney, Nebr., and vicinity. | 19 | | | | | Tornadic winds | Damage to farm building and to winter wheat | Do. |
| Howland, Tex. | 20 | 4:30 p. m. | 200 | | | Tornado | 8 houses and contents destroyed; chickens and hogs killed; 4 persons injured. | Do. |
| Manchester, Tex. | 20 | 5 p. m. | 110 | 2 | 10,000 | do | Property damaged; 19 persons reported injured | Do. |
| Salt River Valley, Ariz. | 20 | P. m. | | | | Snow storm | No details reported | Do. |
| Atlanta, Tex. | 21 | 5 p. m. | 100 | | 1,000 | Tornado | Property damage | Do. |
| McNair, Tex. | 24 | 1:30 p. m. | 133 | | | do | 2 persons injured; houses moved from foundations. | Do. |
| Beaumont, Tex. | 24 | 3 p. m. | 25 | | 1,000 | Wind | No other details | Do. |
| Whitehall, Maurepas and Clio and in southern Tangipahoa Parish, La. | 24 | 3-3:30 p. m. | 200-400 | | 48,300 | Tornado | Several houses destroyed; 20 persons injured; damage to timber and crops; path 35 miles long. | Do. |
| Smithdale, Miss., and vicinity. | 24 | 7 p. m. | 100 | | | do | Loss of livestock; damage to buildings and timber. | Do. |
| Barwick, Ga., and vicinity. | 25 | | 50 | 2 | 76,500 | Tornadic winds | Damage to buildings, livestock and crops | Do. |
| Maurepas, La., and vicinity. | 25 | | | | | Tornado | One house lifted and deposited 200 feet away in swamp; another whirled into river; 20 persons injured. | Do. |
| Sandy Run, S. C. | 25 | | | 1 | | Wind | Loss of life because of fallen tree | Do. |
| Richmond, Va. | 25 | | | | 5,000 | Electrical and wind. | Damage to telephone poles, plate glass windows and trees. | Do. |
| New Jersey coast, Long Branch to Atlantic City and vicinity. | 25-26 | | | 3 | 505,000 | Gale | Bulkheads wrecked, several houses cracked in two, municipal fishing pier washed away at Ventnor Beach; houses flooded; much property damaged. | Do. |
| Philadelphia, Pa. | 25-26 | P. m. | | | 30,000 | Wind | Telegraph poles blown down; property damaged | Do. |
| North Carolina, mainly coast and sound sections. | 25-29 | | | | 86,000 | Gales | Damage mainly to small craft and to highways | Do. |
| New York, N. Y. | 26 | | | | | Wind | Many lives lost; damage to property amounted to millions. | Do. |
| Mendota, Va. | 26 | 7:30-12 p. m. | | | 500 | do | Loss to farm buildings | Do. |
| Coast districts, Maine to Massachusetts. | 26-28 | | | | 2,000,000 | Gales and storm tides. | Water-front property damaged; shore boulevards buried under tons of sand and rocks; sea walls crumbled; permanent changes in shape of coast line. | Do. |
| Florida | 27 | | | | | Wind | Damage to tender truck in southern district | Do. |

[1] Miles instead of yards.

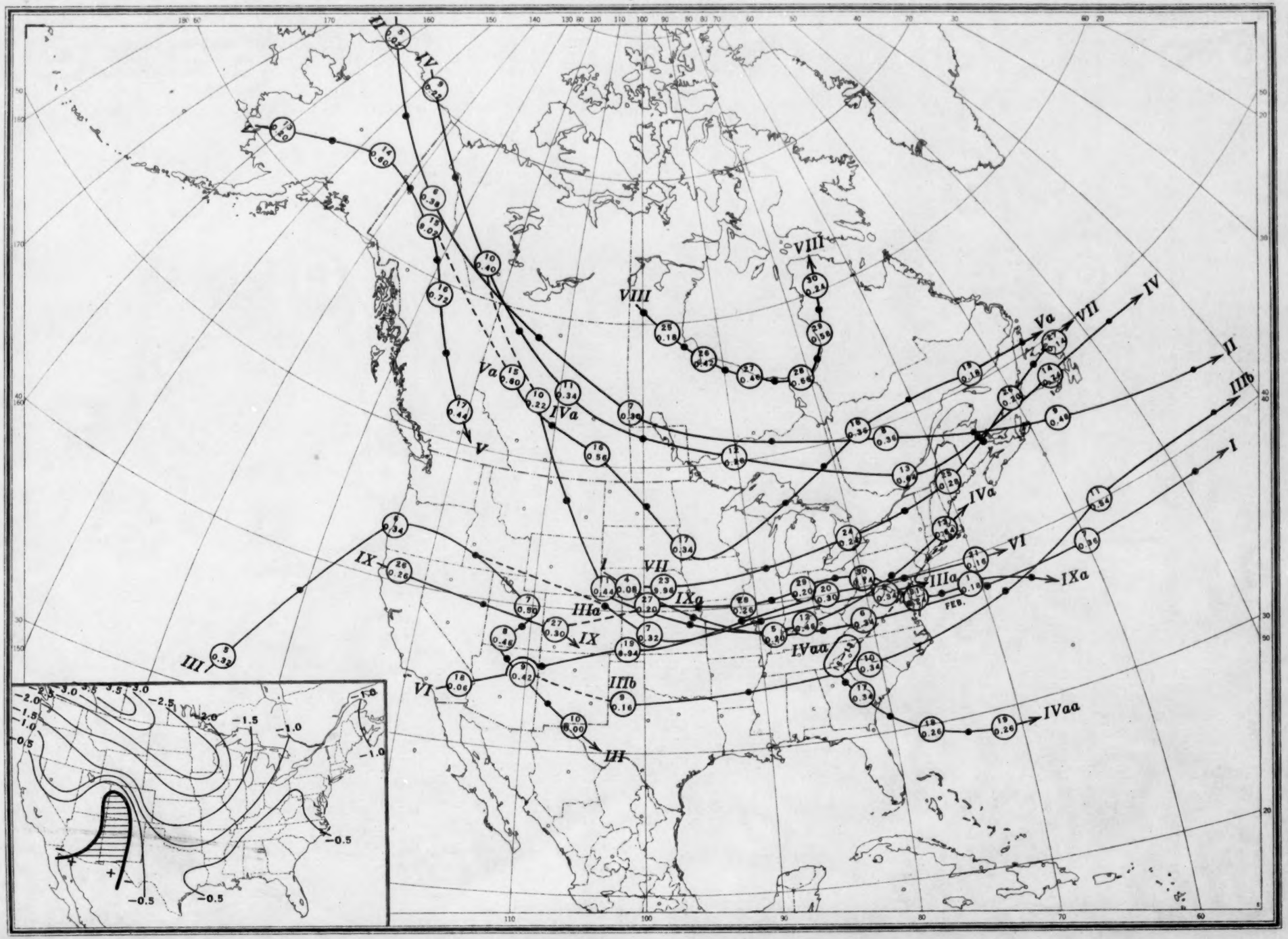
Chart I. Departure (°F.) of the Mean Temperature from the Normal, January, 1933

**Chart I. Departure (°F.) of the Mean Temperature from the Normal, January, 1933**


Shaded portions show excess (+).
Unshaded portions show deficiency (—).
Lines show amount of excess or deficiency.
Statute Miles
Kilometers

## Chart II. Tracks of Centers of Anticyclones, January, 1933. (Inset) Departure of Monthly Mean Pressure from Normal

(Plotted by G. E. Dunn)




Circle indicates position of anticyclone at 8 a. m. (75th meridian time), with barometric reading. Dot indicates position of anticyclone at 8 p. m. (75th meridian time).



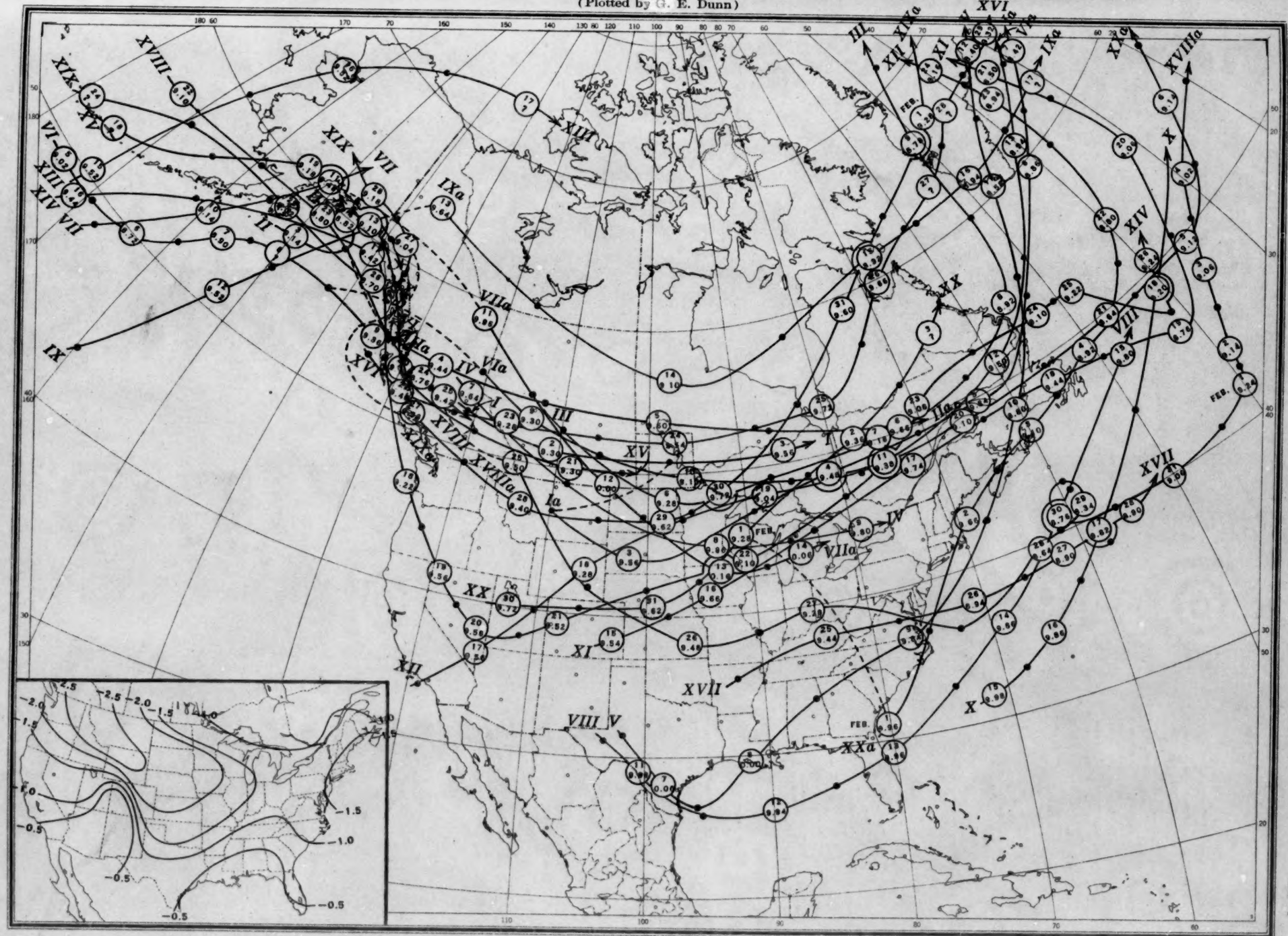
## Chart III. Tracks of Centers of Cyclones, January, 1933. (Inset) Change in Mean Pressure from Preceding Month

(Plotted by G. E. Dunn)

Circle indicates position of anticyclone at 8 a. m. (75th meridian time), with barometric reading. Dot indicates position of anticyclone at 8 p. m. (75th meridian time).

**Chart III. Tracks of Centers of Cyclones, January, 1933.** (Inset) **Change in Mean Pressure from Preceding Month**

(Plotted by G. E. Dunn)




Circle indicates position of cyclone at 8 a. m. (75th meridian time), with barometric reading. Dot indicates position of cyclone at 8 p. m. (75th meridian time).



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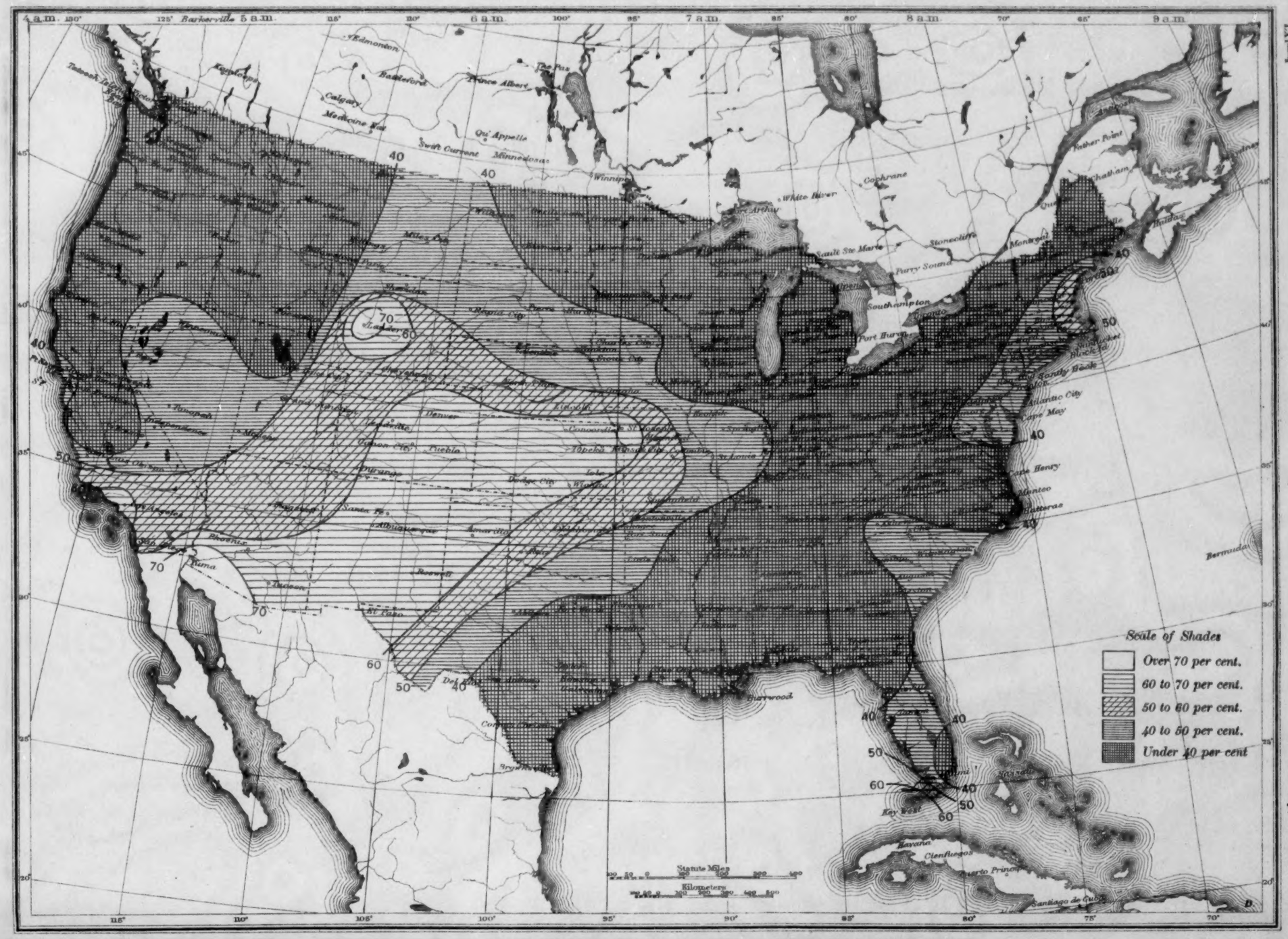
## Chart IV. Percentage of Clear Sky between Sunrise and Sunset, January, 1933






## Chart V. Total Precipitation, Inches, January, 1933. (Inset) Departure of Precipitation from Normal

**Chart V. Total Precipitation, Inches, January, 1933.** (Inset) **Departure of Precipitation from Normal**

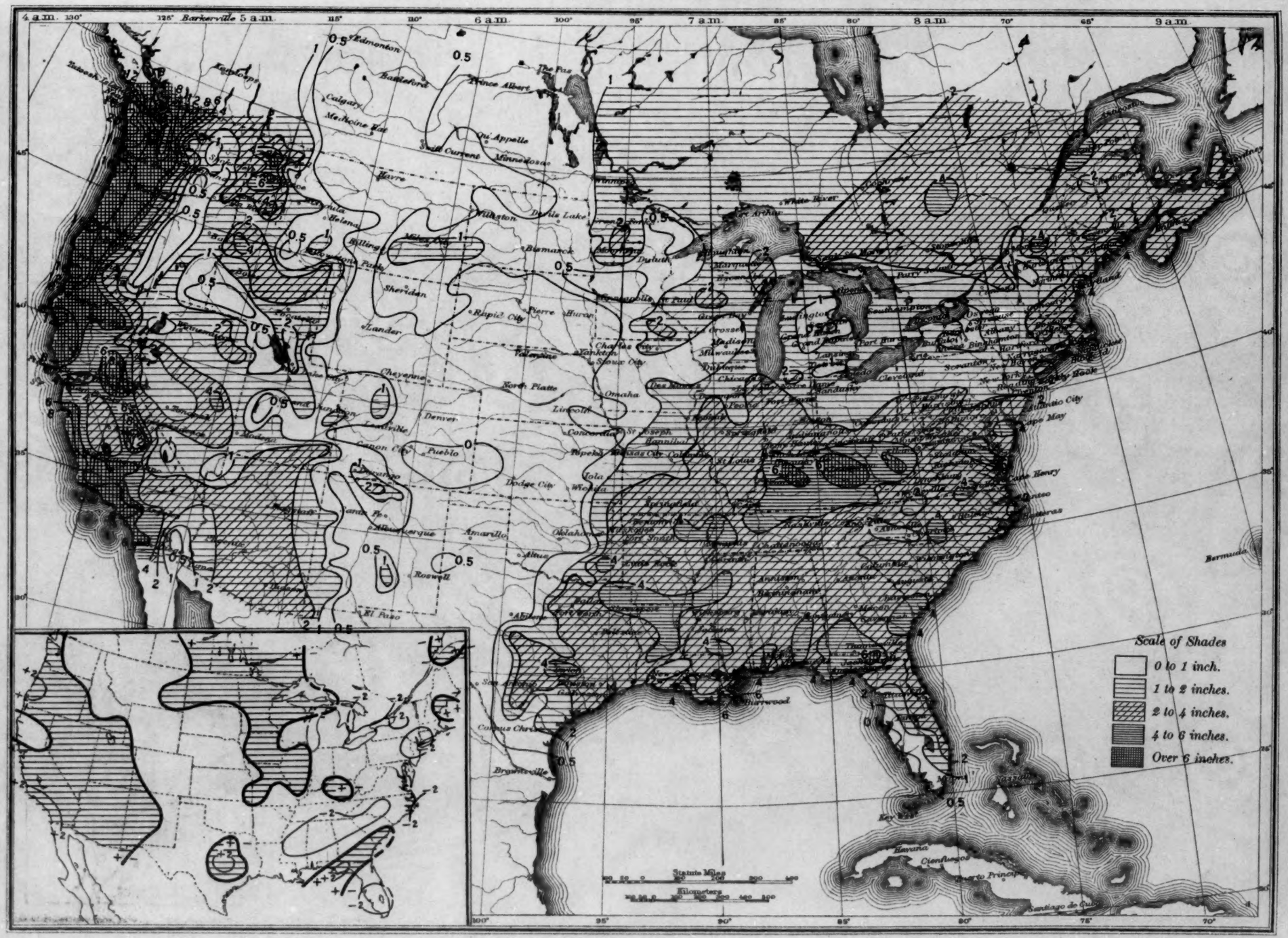


Chart VI. Isobars at Sea level and Isotherms at Surface; Prevailing Winds, January, 1933

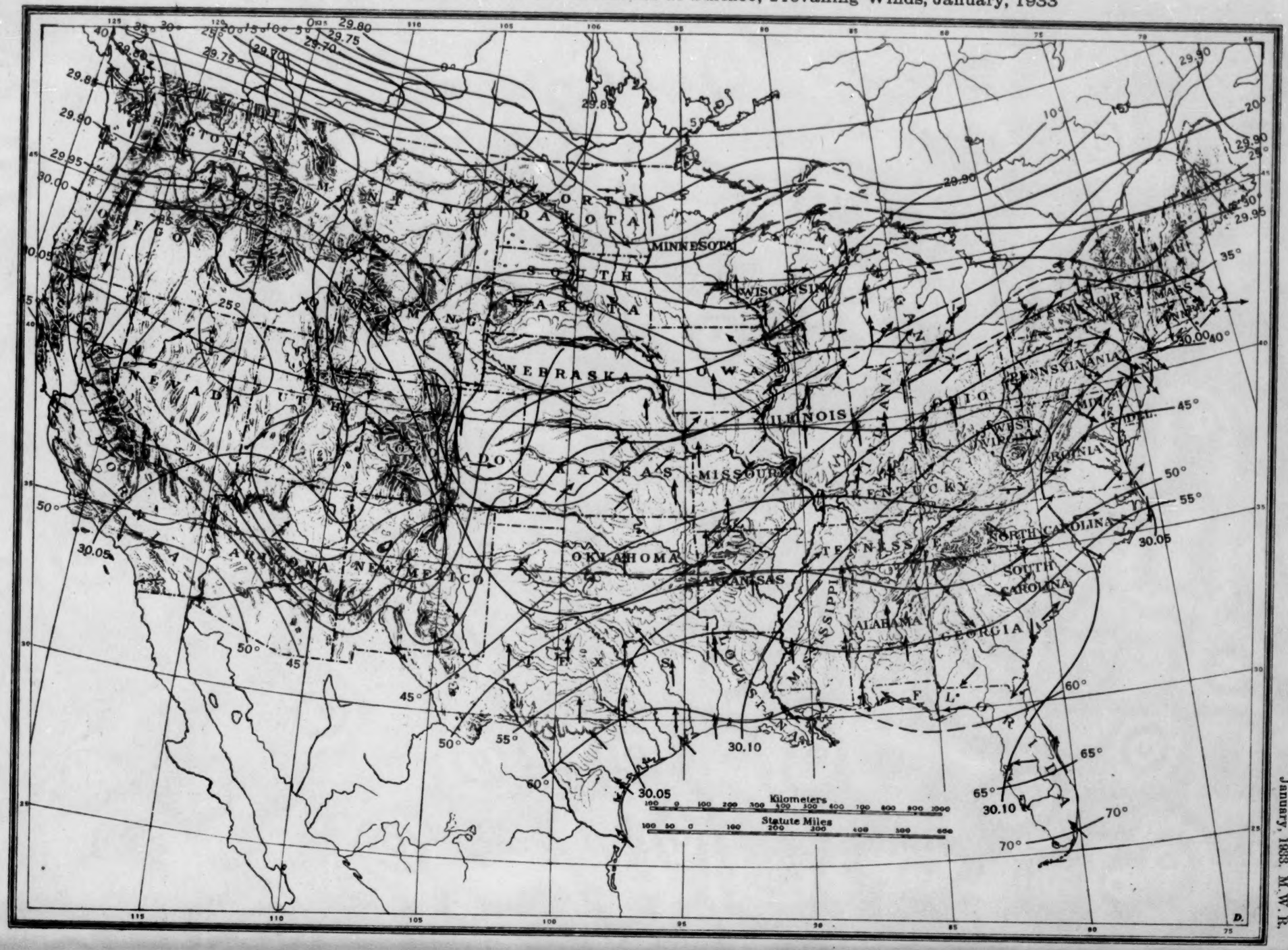






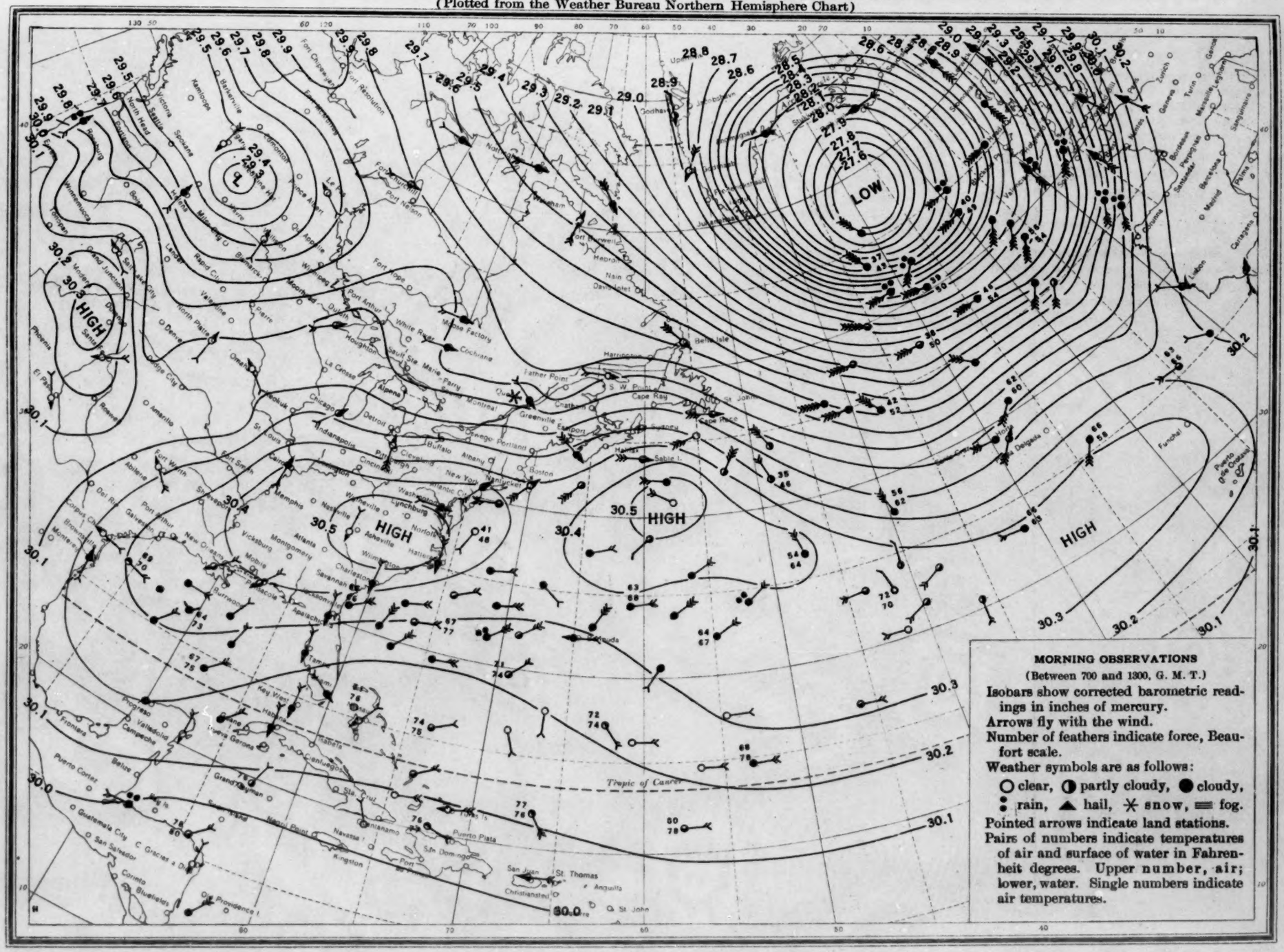

Chart VII. Total Snowfall, Inches, January, 1933 (Inset) Depth of Snow on Ground at 8 a.m., March 1, 1933

Chart VII. Total Snowfall, Inches, January, 1933. (Inset) Depth of Snow on Ground at 8 p. m., Monday, January 30, 1933

Chart VIII. Weather Map of North Atlantic Ocean, January 2, 1933

## Chart VIII. Weather Map of North Atlantic Ocean, January 2, 1933

(Plotted from the Weather Bureau Northern Hemisphere Chart)


LOW
HIGH
HIGH
HIGH
HIGH
Tropic of Cancer
MORNING OBSERVATIONS
(Between 700 and 1300, G. M. T.)
Isobars show corrected barometric readings in inches of mercury.
Arrows fly with the wind.
Number of feathers indicate force, Beaufort scale.
Weather symbols are as follows:
clear, partly cloudy, cloudy,
rain, hail, snow, fog.
Pointed arrows indicate land stations.
Pairs of numbers indicate temperatures of air and surface of water in Fahrenheit degrees. Upper number, air; lower, water. Single numbers indicate air temperatures.



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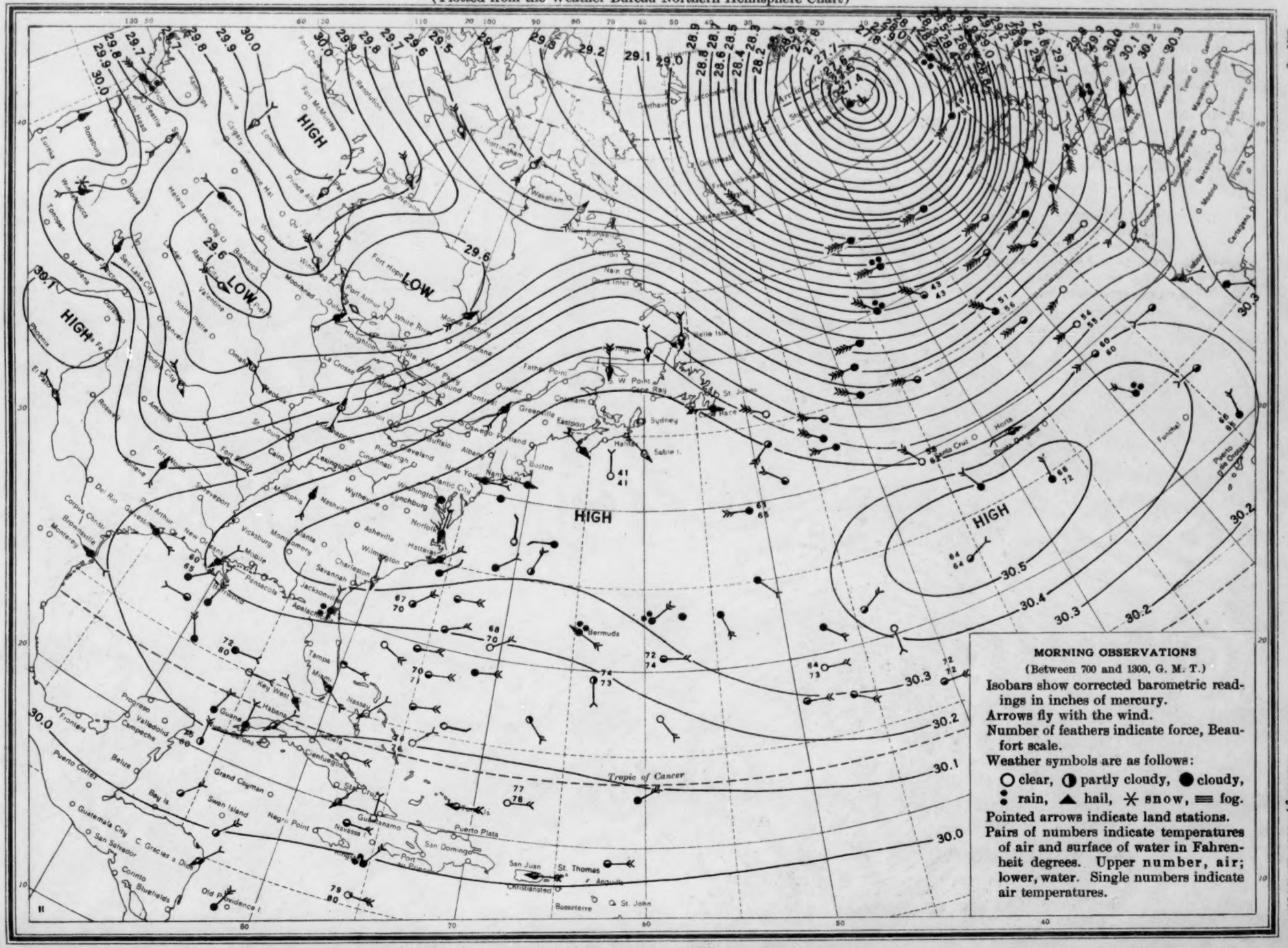
## Chart IX. Weather Map of North Atlantic Ocean, January 3, 1933

(Plotted from the Weather Bureau Northern Hemisphere Chart)

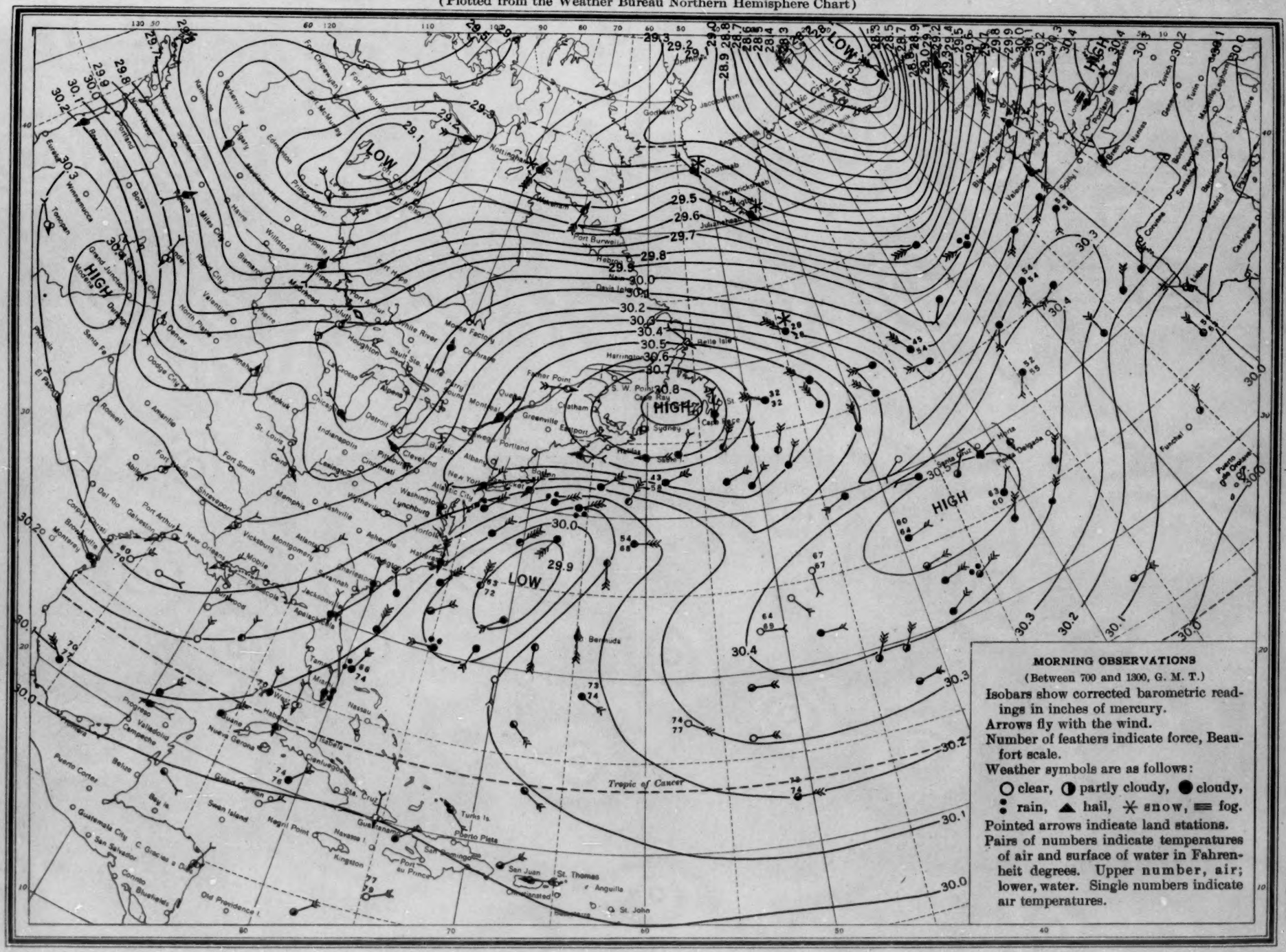

HIGH
LOW
HIGH
LOW
HIGH
HIGH
Tropic of Cancer
MORNING OBSERVATIONS
(Between 700 and 1300, G. M. T.)
Isobars show corrected barometric readings in inches of mercury.
Arrows fly with the wind.
Number of feathers indicate force, Beaufort scale.
Weather symbols are as follows:
clear, partly cloudy, cloudy, rain, hail, snow, fog.
Pointed arrows indicate land stations.
Pairs of numbers indicate temperatures of air and surface of water in Fahrenheit degrees. Upper number, air; lower, water. Single numbers indicate air temperatures.



## Chart X. Weather Map of North Atlantic Ocean, January 14, 1933

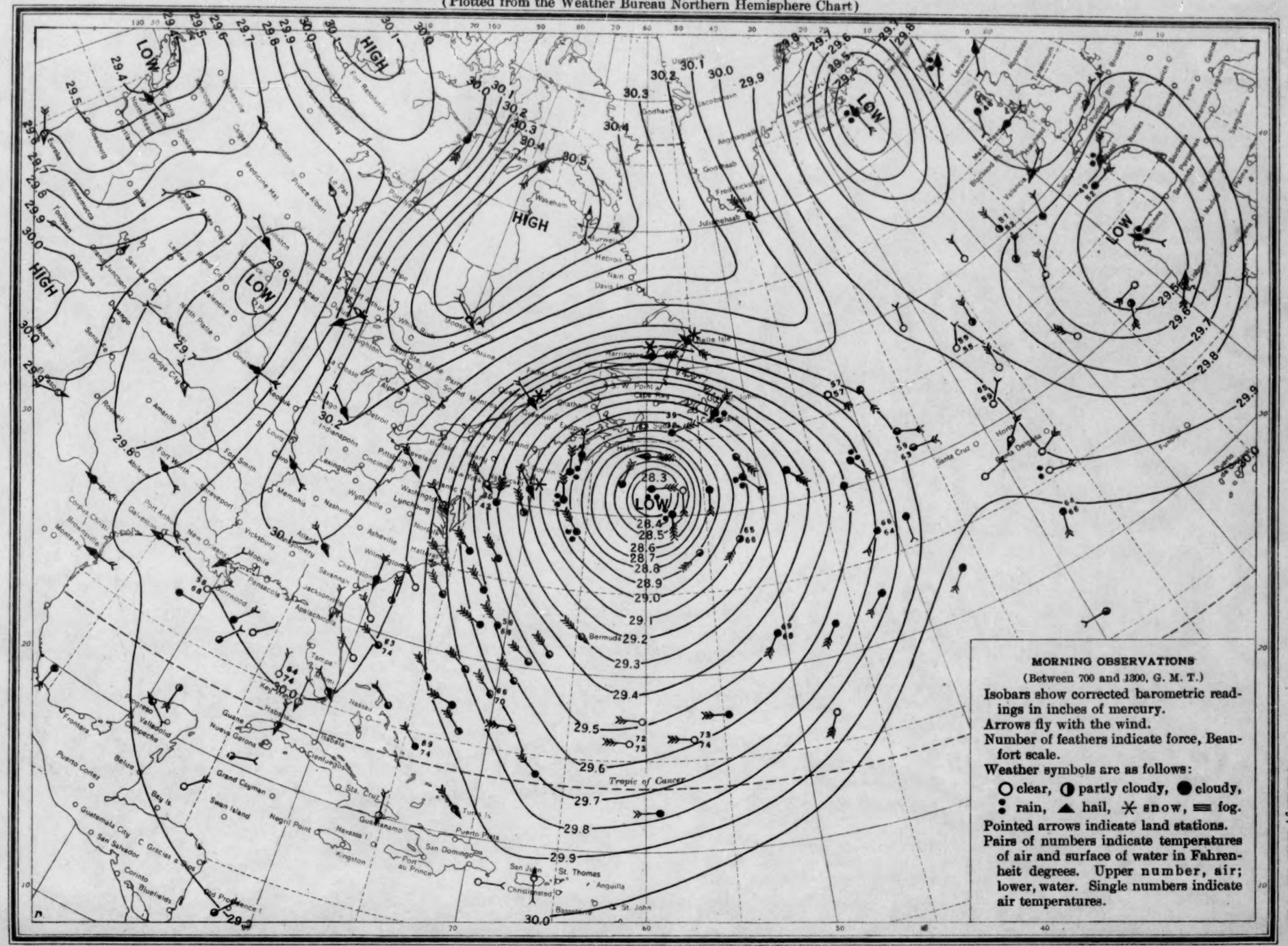
## Chart X. Weather Map of North Atlantic Ocean, January 14, 1933

(Plotted from the Weather Bureau Northern Hemisphere Chart)


LOW
HIGH
LOW
HIGH
LOW
HIGH
Tropic of Cancer
MORNING OBSERVATIONS
(Between 700 and 1300, G. M. T.)
Isobars show corrected barometric readings in inches of mercury.
Arrows fly with the wind.
Number of feathers indicate force, Beaufort scale.
Weather symbols are as follows:
clear, partly cloudy, cloudy,
rain, hail, snow, fog.
Pointed arrows indicate land stations.
Pairs of numbers indicate temperatures of air and surface of water in Fahrenheit degrees. Upper number, air; lower, water. Single numbers indicate air temperatures.

## Chart XI. Weather Map of North Atlantic Ocean, January 29, 1933

(Plotted from the Weather Bureau Northern Hemisphere Chart)


LOW
HIGH
Tropic of Cancer
MORNING OBSERVATIONS
(Between 700 and 1300, G. M. T.)
Isobars show corrected barometric readings in inches of mercury.
Arrows fly with the wind.
Number of feathers indicate force, Beaufort scale.
Weather symbols are as follows:
clear, partly cloudy, cloudy,
rain, hail, snow, fog.
Pointed arrows indicate land stations.
Pairs of numbers indicate temperatures of air and surface of water in Fahrenheit degrees. Upper number, air; lower, water. Single numbers indicate air temperatures.